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Ministry of Transportation

Materials Engineering and Research Office Report

Aggregate and Soil Proficiency Sample Testing Program for 2007

MERO-028

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Abstract	The Materials Engineering and Research Office, Soils and Aggregates Section, conducts a proficiency sample testing program each year to provide a means for participating laboratories to see if they are performing satisfactorily. We also conduct a sample testing program for the tests related to Superpave consensus properties of aggregates. This is conducted along with our annual Aggregate and Soil Proficiency program The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected at the MTO Laboratory. The samples are delivered to the participating laboratories starting in June and they report their results for the aggregate and soil proficiency sample tests starting in the early part of August. A preliminary report issued in mid-September allows the laboratories to examine their procedures or equipment and correct any problems that may have occurred. This is the final report for both the Aggregate and Soil Proficiency Samples and Superpave Consensus Property Testing for 2007. This year there were two hundred and seven laboratories participating from the private and public sector in the Aggregate and Soil Proficiency Sample Testing Program. Fifty-seven laboratories from the private sector and MTO Downsview laboratory reported results for the Superpave consensus property tests. Results of the 2007 Aggregate and Soil Proficiency Sample Program are found to be consistent with the results reported in the last three years but in some of the tests, the variations show noticeable improvements compared to previous years' results. Although there is marked improvement in results, strong laboratory biases still remain in many of the test procedures. The variations in the results for the Superpave Consensus Property Testing program are found to be consistent with the values published in ASTM precision statements.
Key Words	Aggregate, consensus property, correlation, laboratory, proficiency testing, soil, Superpave
Distribution	Unrestricted technical audience.

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Published without prejudice as to the application of the findings.

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Executive Summary

The Soils and Aggregates Section of the Materials Engineering and Research Office runs an annual proficiency sample-testing program for aggregate and soil tests. This provides a means for participating laboratories to see if they are performing satisfactorily. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected by the MTO Soils and Aggregates Laboratory. The samples are delivered to the participating laboratories starting in June. The laboratories report their results in August. A preliminary report issued in mid September gives feedback to the participants while they are still operational in the current year. This allows them to examine their procedures or equipment and correct any problems that may have occurred. A final report is issued after analysis of the data has been completed.

This is the final report for the 2007 MTO Aggregate and Soil Proficiency Sample Testing and the Superpave Aggregate Consensus Property Testing Programs. This year, there were two hundred and seven (207) laboratories from the private and public sector participating in the Aggregate and Soil Proficiency Sample Testing Program. Of these, one hundred and fifty were aggregate producers' and road builders' Quality Control (QC) Laboratories. The remainder were engineering testing consultants and owners' laboratories. Participation in this program is required by the contract documents if contractor's QC process is to be acceptable to MTO. In general, these contractor and supplier laboratories are conducting particle size analysis, wash pass 75 μm, percent crushed particles, percent asphalt coated particles, and density tests for granular base and sub-base aggregates.

Fifty-eight laboratories reported results for the Superpave Aggregate Consensus Property Testing Program in 2007. The laboratories that participate in this program conduct uncompacted void content of fine aggregate, sand equivalent value of fine aggregate, percent of fractured particles in coarse aggregate, and flat particles, elongated particles, or flat and elongated particles in coarse aggregate tests, in accordance with the ASTM/AASHTO test methods.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (*i.e.* a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating for each category of tests. This rating system has acted as an incentive for laboratories to improve their performance. The rating is also used as a guide by MTO to select laboratories for its quality assurance testing and for qualifying referee laboratories.

Results of the 2007 Proficiency Sample Program are found to be consistent with the results from previous years and in some of these tests, the results show improvements compared to previous years' results and precision estimates published by ASTM/AASHTO. Particularly, wash pass 75 μm, Los Angeles abrasion, percent flat and elongated particles of coarse aggregate, and Micro-Deval abrasion (fine) show improvements over previous years.

Although there is noticeable improvement in the precision of most of the test methods compared to previous years, strong laboratory biases still remain in some of the test methods. The variations in soil test results are consistent with the values reported in the previous three years of study, but the scatter plots show a strong laboratory bias.

The majority of the laboratories who participated in the 2007 Superpave aggregate tests have been participating in this program for the past five to six years. They have now gained experience with these test procedures. The variations of all four tests are consistent with the values published in ASTM precision statements. However, the scatter diagrams for all four tests show strong laboratory biases.

The Soils and Aggregates Section continues to carry out the inspection of laboratories providing soil testing services to the ministry. This inspection is being done at the request of laboratories. The laboratories that are inspected and accepted by MTO must request a re-inspection whenever technicians or equipment change. To date, thirty-eight laboratories have been inspected; of which thirty-four laboratories have been approved to do testing of soils for MTO work.

1. Introduction

This is the final report of the 2007 inter-laboratory testing program organised by MTO for aggregate and soil test methods. It is primarily intended to provide a means for laboratories used by MTO to see if they are performing satisfactorily and to qualify these laboratories to perform quality control and quality assurance testing for MTO contracts[1]. The design of the testing program is based on procedures for determining the precision and variability of test methods. Interested readers should refer to ASTM C670[2], C802[3], E177[4] and E178[5] for further information on inter-laboratory testing programs.

There were a total of two hundred and seven laboratories participating in the Aggregate and Soil Proficiency Sample Testing Program, conducted in the summer of 2007. The participants were also asked to submit results for Superpave aggregate consensus property tests, if they were equipped to perform those tests. Fifty-two laboratories submitted results for all of the tests related to the consensus properties. Participants in both testing programs included the MTO laboratory, the remainder being from the private sector (contractors, aggregate producers and engineering consultants) and municipalities. Samples were delivered to laboratories in early June. A preliminary report for both programs, Aggregate and Soil Proficiency Sample Testing and Superpave Consensus Property Testing, was issued in mid September. This document is the final report for both programs.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (*i.e.* a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

The computer program that was developed by MTO to handle the computation and presentation of test data has two statistical methods, namely the Critical Value Method and the Iterative (Jack Knife) Technique, to detect outlying observations or outliers in a set of data. For details of the program refer to the User's Manual (MERO Report No. 13) by Vasavithasan and Rutter, 2004. A number of statistical methods are available to test the hypothesis that the suspect observations are not outliers but the MTO study follows the Critical Value Method recommended in Section 4 of ASTM E 178. The critical value method and iterative techniques are based on two different statistical approaches. As a result, the confidence intervals yielded by these two methods differ widely depending on the number of observations (number of laboratories participating in a particular test method) and the distribution of data.

1 Laboratories must also be inspected and recognised by the Canadian Council of Independent Laboratories (CCIL).
2 ASTM C670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials.
3 ASTM C802 Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods of Construction Materials.
4 ASTM E177 Practice for Use of Terms Precision and Bias in ASTM Test Methods.
5 ASTM E178 Practice for Dealing with Outlying Observations.

The critical value used in this study is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all observations in the sample come from the same normally distributed population. The critical values provided in ASTM E 178, Table 1 are limited to 147 observations, but over 200 laboratories participate in our annual Proficiency Sample Testing Program. The critical values that are being used for the MTO study were calculated at five percent significance level (Grubb's test) based on Grubbs (1969 and 1972) recommendations for identifying outliers. The Jack Knife method recommended by Manchester (1979) is used where the strict application of the critical value method tends to include results that may not stand the best chance of representing the testing performed in conformance with each of the test methods.

2. Test Results

2.1 TABLE OF TEST RESULTS

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Tables 1, 2, 3, and 4. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.

Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples.

Columns 4 and 5 show the mean (average) test value for each sample, for all laboratories performing the test, after removal of outliers and/or invalid test data.

Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\overline{X}$) from the actual test result reported by the laboratory (X_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized deviate} = \frac{\left(X_i - \overline{X}\right)}{s}$$

If the test result is less than the mean, the standardized deviate is negative, and if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

Rating 5 - data within 1.0 standard deviation of the mean.
Rating 4 - data within 1.5 standard deviations of the mean.
Rating 3 - data within 2.0 standard deviations of the mean.
Rating 2 - data within 2.5 standard deviations of the mean.
Rating 1 - data within 3.0 standard deviations of the mean.
Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the other test result is still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.

An outlying observation is one that appears to deviate markedly from the sample population. It may be merely an extreme manifestation of the random variability inherent in the data or may be the result of gross deviation from the prescribed experimental procedure, calculation errors or errors in reporting data. The outlier criteria employed for exclusion of test results

from the analysis will depend on the distribution of data and the number of participants in a test. The iterative technique is one of the methods employed in this study for the selection of outliers, and is used where the strict application of critical value method tends to include the data that does not belong to the population. In the critical value method, the standardized deviate of a lab result is compared with the critical value corresponding to the number of participants in that particular test, for rejecting an outlier. The critical value is greater than 3 when the number of participants in a particular test method is 30 or more. For this reason, results with more than 3 standardized deviates may not have been identified as an outlier unless it is higher than the critical value, but a zero rating is nevertheless assigned for the test result in question. For example, if the computed standardized deviate for a lab result is 3.236 and the critical value corresponding to the number of participants in that particular test is 3.427, the lab will not be identified as an outlier but a zero rating will be assigned.

Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure, *e.g.* sieve analysis, should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

2.2 SCATTER DIAGRAMS

Youden scatter diagrams are supplied with this report (see Appendices D1 and D2). A laboratory can locate itself on the diagrams by plotting its test value for the first sample (1.07) on the horizontal axis, against its test value for the second sample (2.07) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, the outlying results plot outside the boundaries of the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal cross hairs on the plots represent the mean values for all the results on the first sample (1.07) and the second sample (2.07), respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This occurs because laboratories tend to get high or low results on both samples. This gives evidence of individual laboratory biases. As the tendency to laboratory bias increases, the

departure from the expected circular distribution of points towards a linear distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 gives examples of scatter diagrams.

Table 1. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: November 1, 2007					
COARSE AGGREGATE REFERENCE SAMPLES 1.07 & 2.07								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.07	2.07	1	2	1	2	1	2
LS-601 Wash Pass 75 μm (Coarse Aggr.)	0.820	0.910	0.798	0.805	0.130	0.710	5	5
LS-602 – Coarse Aggregate								
Percent Passing 19.0 mm	92.400	91.800	93.812	92.810	-0.989	-0.584	-5	-5
Percent Passing 16.0 mm	76.900	75.300	77.674	74.643	-0.390	0.192	-5	5
Percent Passing 13.2 mm	59.200	57.700	60.770	57.078	-0.649	0.152	-5	5
Percent Passing 9.5 mm	34.900	33.300	33.274	30. 958	0.742	0.754	5	5
Percent Passing 4.75 mm	5.010	4.520	4.484	4.337	0.880	0.270	5	5
LS-603 Los Angeles Abrasion %	23.800	23.000	23.456	23.500	0.487	-0.445	5	-5
LS-607 Percent Crushed Particles	61.000	60.000	65.236	66.835	-0.662	-1.093	-5	-4
LS-608 % Flat & Elongated Particles	10.100	12.300	15.332	15.557	-1.190	-0.756	-4	-5
LS-609 Petrographic Number (Concrete)	110.80	112.50	113.6	112.7	-0.492	-0.025	-5	-5
LS-614 Freeze - Thaw Loss, %	4.300	4.400	4.528	4.276	-0.228	0.146	-5	5
LS-618 Micro-Deval Abrasion Loss (CA)	13.100	13.400	12.228	12.422	1.240	1.469	4	4
LS-620 Accelerated Mortar Bar (14 Days)								

Blank spaces represent not tested.
* - Calculation considered outlier

Table 2. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 DATE PREPARED: November 1, 2007

FINE AGGREGATE REFERENCE SAMPLES 1.07 & 2.07

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.07	2.07	1	2	1	2	1	2
LS-623								
Maximum Wet Density (g/cm^3)	2.429	2.429	2.382	2.385	1.224	1.360	4	4
Maximum Dry Density (g/cm^3)	2.270	2.270	2.223	2.226	1.331	1.285	4	4
Optimum Moisture, %	7.000	7.000	7.369	7.342	-1.154	-1.071	-4	-4
LS-604 – Coarse Aggregate								
Relative Density (O.D)	2.671	2.671	2.683	2.684	-1.737	-2.025	-3	-2
Absorption	0.550	0.550	0.497	0.494	0.803	0.705	5	5
LS-621								
Asphalt Coated Particles, %	29.000	31.100	29.477	29.431	-0.099	0.355	-5	5

Blank spaces represent not tested.
* - Calculation considered outlier

Table 3. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 DATE PREPARED: November 1, 2007

FINE AGGREGATE REFERENCE SAMPLES 3.07 & 4.07

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	3.07	4.07	3	4	3	4	3	4
LS-605 – Fine Aggregate								
Relative Density (O.D)	2.616	2.601	2.611	2.601	0.517	0.008	5	5
Absorption	1.740	2.000	1.849	1.993	-0.664	0.048	-5	5
LS-606 – Coarse Aggregate MgSO4 Soundness Loss, %	2.100	1.800	3.328	3.181	-1.125	-1.380	-4	-4
LS-606 – Fine Aggregate MgSO4 Soundness Loss, %	18.300	19.800	14.816	15.353	0.747	1.031	5	4
LS-619- Fine Aggregate Micro-Deval Abrasion	17.300	17.400	16.810	16.743	0.451	0.785	5	5
LS-602 – Fine Aggregate								
Percent Passing 2.36 mm	93.400	91.400	92.945	93.044	0.496	-2.488	5	-2
Percent Passing 1.18 mm	70.100	66.700	68.126	68.421	1.015	-1.034	4	-4
Percent Passing 600 μm	32.300	30.900	33.212	33.488	-0.432	-1.363	-5	-4
Percent Passing 300 μm	9.300	8.800	9.467	9.403	-0.149	-0.830	-5	-5
Percent Passing 150 μm	2.600	2.500	2.731	2.651	-0.299	-0.410	-5	-5
Percent Passing 75 μm	1.540	1.480	1.671	1.576	-0.426	-0. 314	-5	-5

Blank spaces represent not tested.
* - Calculation considered outlier

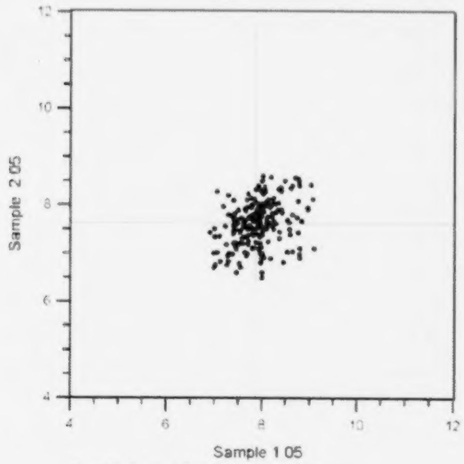
Table 4. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 — DATE PREPARED: November 1, 2007

SOILS REFERENCE SAMPLES 1.07 & 2.07

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.07	2.07	1	2	1	2	1	2
LS-702 – Sieve Analysis of Soil								
Percent Passing 2.00 mm	99.900	100.00	99.956	99.967	-	-		
Percent Passing 425 µm	97.500	98.000	97. 014	97.076	0.837	1.709	5	3
Percent Passing 75 µm	92.900	93.500	91.628	91.670	1.568	2.350	3	2
Percent Passing 20 µm	78.800	78.500	78.675	78.749	0.036	-0.061	5	-5
Percent Passing 5 µm	60.000	59.000	59.242	59.440	0.269	-0.137	5	-5
Percent Passing 2 µm	41.800	42.000	44.034	44.570	-0.649	-0.766	-5	-5
LS-703								
Liquid Limit, %	37.400	37.600	37.032	37.190	0.233	0.276	5	5
LS-704								
Plastic Limit, %	19.300	19.400	18.952	19.144	0.262	0.270	5	5
Plasticity Index, %	18.100	18.200	18.112	18.112	-0.009	0.062	-5	5
LS-705								
Specific Gravity of Soil	2.712	2.708	2.731	2.732	-0.713	-0.920	-5	-5
AGGREGATE CONSENSUS PROPERTIES								
Uncompacted Void Content	41.800	41.400	41.321	41.209	0.688	0.366	5	5
Sand Equivalent Value	96.200	97.400	90.548	90.819	1.617	1.753	3	3
Percent Fractured Particles	72.100	69.300	66.972	67.856	1.394	0.316	4	5
% Flat & Elongated Particles	3.200	3.800	4.416	4.530	-0.653	-0.367	-5	-5

Blank spaces represent not tested.
* - Calculation considered outlier

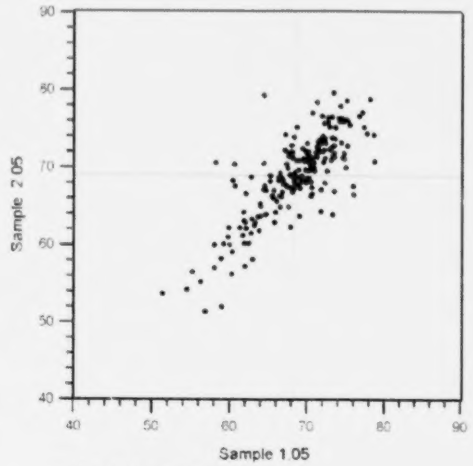


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	7.930	7.630
Median	7.800	7.500
Std Dev	0.460	0.470
n = 203		

Labs Eliminated 447, 497, 452, 518

Scatter diagram for a test showing random variation with little laboratory bias

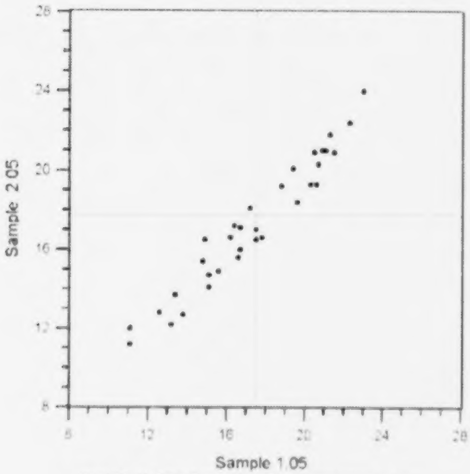


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	68.491	68.905
Median	68.300	64.500
Std Dev	5.054	5.402
n = 201		

Labs Eliminated 345, 350, 436, 480

Scatter diagram for a test showing a combination of random variation and laboratory bias for some laboratories

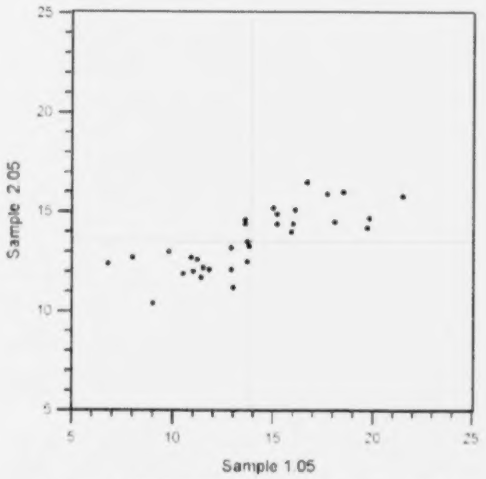


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	17.370	17.258
Median	15.800	15.600
Std Dev	3.276	3.326
n = 32		

Lab Eliminated: None

Scatter diagram for a test showing pronounced between laboratory bias and equal variation for each material



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	13.890	13.570
Median	12.900	13.600
Std Dev	3.533	1.541
n = 31		

Lab Eliminated: None

Scatter diagram for a test with pronounced between laboratory bias but unequal variation for each material

Figure 1. Examples of Scatter Diagrams

2.3 OUTLIERS

In dealing with suspected outlying observations or 'outliers', our purpose is to remove those observations that do not belong to the sample population and to provide some statistical criteria for doing so. There are a number of ways to do this. In most of these, as ASTM E178 states, 'the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected. The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution or universe.

The MTO study follows the criteria recommended for single samples in Section 4 of ASTM E 178 for rejecting the doubtful observations at the ninety-five percent confidence level. The critical value method is based on the assumption of normality and the critical values are calculated using Student's t distribution. The assumption in this method is that all the observations come from the same normal population. The doubtful observation is included in the calculation of mean and standard deviation of the population. Then the critical value, T_n, for that observation, n, in question is calculated and compared with the critical value based on the theory of random sampling. The doubtful observation is rejected if T_n is higher than the critical value for the five percent significance level. The outlier is removed from the data set and the iterations are continued until no outliers are detected, and a revised mean and standard deviation are calculated after deleting the outlier. The ratings of the laboratories are determined based on the revised mean, standard deviation and standardised deviate.

In some cases, the strict application of the critical value method tends to include laboratories in the population who are not doing a good job. In those cases, the application of the iterative technique (Manchester[6]) is used. In the iterative technique, the Constant C is computed using Fisher's F distribution, and C depends on the number of participating laboratories. In this technique, an outlying observation is rejected based on a statistical criterion but the confidence interval may vary depending on the number of participants and the distribution of sample population.

In the iterative technique, after screening the test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and test result farthest from the mean by a unit of Cs (standard deviation (s) multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of critical value method.

6 The Development of an Interlaboratory Testing Program for Construction Aggregates, by L. Manchester, Ministry of Transportation, Ontario, Engineering Materials Office Report EM-33, Downsview, December, 1979.

3. Discussion

The following discussion contains general and test-specific comments for the 2007 test period. Where ASTM or AASHTO precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in Appendix A.

3.1 NOTES ON MATERIAL SOURCES

Materials used in this test period were as follows:

- Fine aggregate tests, including Sieve Analysis, Relative Density and Absorption, Micro-Deval Abrasion Loss, Magnesium Sulphate Soundness, Uncompacted Void Content, and Sand Equivalent Value - Sutherland Gowanlock Pit Sand from Flesherton, Ontario (MTO MAIDB No. C11-121).
- Coarse Aggregate tests, including Wash Pass 75 µm, Sieve Analysis, Percent Crushed Particles, Relative Density and Absorption, Petrographic Analysis, Magnesium Sulphate Soundness, Freeze-Thaw, Los Angeles Abrasion, Micro-Deval Abrasion Loss, and Percent Fractured Particles - Beach Gravel from CBM Brighton Pit (MTO MAIDB No. T07-174).
- Percent Flat and Elongated Particles, and Percent Flat, Elongated, or Flat and Elongated Particles - 13.2 mm Concrete Stone from Walker Brothers, Vineland Quarry (MTO MAIDB No. N03-023).
- Moisture Density Relationship – Granular 'A' from Oak Ridges Moraine, Vicdom Sand & Gravel, Goodwood Pit (MTO MAIDB No. N02 - 124)
- Fine Aggregate Petrographic Examination - Scalped sand from the Barino Construction pit (MTO MAIDB Number L05-040) North of Longlac.
- Soil tests – Glacial Lake Iroquois deepwater laminated silt and clay from Walker Brothers Vineland I Quarry, N03-023.

3.2 NOTES ON SAMPLE PREPARATION

In 2007, the samples for the coarse and fine aggregate tests were processed separately. The material processed for the coarse aggregate tests conforms to the gradation requirements of structural concrete. The gradation of the fine aggregate supplied conforms approximately to that of concrete sand. The aggregate samples were prepared using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory (refer to Figures 2 and 3 of Report MI-179, February 2000). A bobcat loader was used to fill an aggregate bin with

small scoops from the stockpile and the material was fed along a conveyor belt to fill 30 identical bags (fitted with funnels) on a spinning turntable. It was found that 18 to 20 revolutions of the turntable were required to fill each bucket to 24 ± 2 Kg of coarse aggregate. This resulted in more homogeneity of the samples than would normally be the case using other techniques. In total, five hundred 24 ± 2 Kg samples were prepared for the coarse aggregate tests, and randomised for distribution to participating laboratories.

However, the number of revolutions of the turntable required for fine aggregate to fill each bucket to approximately 12 Kg was found to be higher (24 to 28) than that of the coarse aggregate. In total, five hundred 12 ± 2 Kg samples were prepared for the fine aggregate tests, and randomised for distribution to participating laboratories.

The soil was air-dried, processed passing 2.0 mm using a Fritsch Soil Mill Pulverizer, and placed in 20 Kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter. The hopper of the spinning riffle used is capable of filling 24 identical 2 Kg containers per run. This method was used to create uniform 20 Kg buckets. The correlation material was then prepared by obtaining representative samples from a 20 Kg bucket. The material collected from the 20 Kg bucket was then transferred to the hopper of the spinning riffle and the 500 g correlation samples were prepared. Then the samples were randomised for distribution to participating laboratories. The use of a spinning riffler ensured that as far as possible, each sample was identical to every other sample. It has been found that this is the best technique for minimising sample bias.

3.3 NOTES ON INDIVIDUAL TESTS

For each test, comments have been made pertaining to the variation illustrated by the scatter diagram. The technique used to test for outliers is stated and where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables found in the Appendix C. Besides the comparison made to ASTM precision statements, comparison of the variation between test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasised that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test normally exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.4 PROFICIENCY SAMPLE TESTS

3.4.1 Wash Pass 75 µm (Coarse Aggregate) – Test No. 1

Two hundred and five laboratories participated in this test in 2007. Six outliers were identified and rejected using the critical value method. The standard deviations obtained in 2007 are considerably lower than that of the values in 2005 and 2006, and the multi-laboratory variation published by ASTM for aggregates with less than 1.5% material finer than 75µm. The scatter diagram shows a random variation with laboratory bias for some laboratories. The laboratories that are identified as outliers or with a zero rating should examine their test procedure more closely, especially the achievement of constant dry mass at the beginning and end of the test.

3.4.2 Sieve Analysis (Coarse Aggregate) – Test Nos. 2-6

The samples supplied for the coarse aggregate tests consisted of 98% of the material retained on 4.75 mm sieve, and differ from the grading of materials (Granular 'A') used in the past MTO proficiency testing programs. The Test Nos. 2-6 represents the complete grading of coarse aggregate used in 2007 program. The data is presented in percent passing format and is compared to precision statements developed in the same format by Vogler and Spellenberg[7].

The samples were prepared with a large spinning riffler that is described in Section 3.2. This method of preparation minimises the sample variation and has resulted in no observable average gradation difference between samples 1.07 and 2.07. The variations found in 2007 for the coarse sieves are significantly higher than that of the values obtained in the past four years. However, the standard deviations obtained for most of the sieves are comparable to that of the expected variations given in the ASTM precision statements. Considering the type of material used and the amount of material retained on each sieve, it may not be appropriate to compare the variations obtained in 2007 with the results of the past programs.

Two hundred and five laboratories performed the sieve analysis test in 2007. Outliers were eliminated using the critical value method. Successive scatter diagrams show a fairly uniform distribution of points about the mean. The number of outliers identified varies from sieve to sieve, and it ranges from two for 19.0 mm sieve to a maximum of five for the 9.5 mm and 4.75 mm sieves.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), efficiency of the sieving process and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (use CAN/CGSB-8.1-88 or ASTM E-11 as guides) and your sieve shaker(s) thoroughly, and once satisfied that they are in order, perform a sieving efficiency test (MTO Method LS-602, Revision No. 23) to pinpoint any problems.

7 Vogler, R.H., Department of Transportation, Michigan, AASHTO Technical Section 1c: T27 and Spellenberg, P.A., AASHTO Materials Reference Laboratory; Unpublished Paper.

3.4.3 Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Only ten laboratories participated in this test. One outlier was detected by the use of iterative technique. Considering the number of observations (10) used, the analysis may not yield a meaningful or representative statistical data. The lower left and upper right quadrants together account for seven of the ten points, which is evidence of significant laboratory biases. This test shows systematic variation, as was found in previous years. However, the variations in 2007 are considerably lower than that of the values found in the past studies, and the coefficient of variation published in the ASTM precision statement.

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range 10 to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, results from two different laboratories should not differ by more than 12.7%. The mean in this test (23.5%) is in the range of values for which ASTM data was established. This year's coefficient of variation (average 3.9%) is lower than that of the value given in the ASTM precision statements. The multi-laboratory variation obtained in 2007 indicates an improvement in the performance of the laboratories participating in this test.

3.4.4 Relative Density (Coarse Aggregate) - Test No. 9 and Absorption (Coarse Aggregate) – Test No. 10

Ninety-six laboratories participated in these tests in 2007. Six laboratories in Test No. 9 and one laboratory in Test No. 10 were eliminated using the critical value method. The standard deviations obtained for bulk relative density (Test No. 9) are consistent with that of the values found in the past three years, and are considerably less than the values given in the ASTM precision statements. A similar trend was observed in the absorption test (Test No. 10). The variation obtained in 2007 is similar to that of the values reported in 2006 and 2004, and are almost one-half of the values reported in 2005 and that of the precision estimate provided in ASTM. The latest version of ASTM C 127 - 04 does not provide precision estimate for the absorption test. The expected variation shown on the precision table in Appendix C is based on the previous publication C 127 - 88. The scatter diagrams for both of these tests show a combination of random variation and laboratory bias for some laboratories.

3.4.5 Magnesium Sulphate Soundness (Coarse Aggregate) – Test No. 11

Thirty-seven laboratories reported results for this test in 2007. Only one outlier was identified by the use of both, critical value method and iterative technique. The scatter diagram shows a strong laboratory bias and all the points, with the exception of eight, are accounted in the lower left and upper right quadrants. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The coefficient of variations obtained in 2007 (32.3%) is slightly higher than the value reported in 2005 (24.9%) and 2006 (28.6%), but comparable to that of the value reported in 2004 (34.9%). The mean in this test (3.3%) is well below the values for which ASTM precision estimate was established, but the variations are noticeably higher than the value published in the ASTM precision statements. ASTM reports a multi-laboratory coefficient of variation of 25% for coarse aggregate with percent

loss in the range of 9 to 20%.

3.4.6 Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

Two hundred and five laboratories performed the percent crushed particles test in 2007. Four outliers were selected by employing the critical value method. Variation (6.3%) is consistent with the value (6.0%) obtained during 1989 MTO workshop. The mean in this test (66.0%) is within the range of values (50% to 75%) for which the MTO precision statement was established. The variation in 2007 is slightly higher than the values obtained in the past three years. The scatter diagram shows a random variation with noticeable laboratory operator bias. The samples distributed did not contain any cemented particles; therefore the percent cemented particles test was not evaluated this year. ASTM has a very similar test method (D 5821) but has not conducted inter-laboratory studies to determine precision and currently publishes precision data (standard deviation of 5.2% for a mean value of 76.0%) obtained from MTO.

3.4.7 Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the *greatest* length or width to thickness ratio. The MTO procedure previously measured the *mean* length or width to the *mean* thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants should be using the latest MTO version of the test.

The participants in the 2007 program were advised to test the material supplied for this test as a single sample. When the material is tested as a single sample, there is no need to separate the test sample into number of fractions and test and also, no need for calculation of weighted average. The laboratories were given material processed separately for this test, but the participants were asked to hand sieve the samples to remove the material retained on 13.2 mm and passing the 4.75 mm sieves, and test the remaining material as a single sample.

One hundred and sixty six laboratories reported results for this test in 2007. The iterative technique was used to reject two outliers. ASTM and CSA do not report precision for this test method. MTO Test Method LS-608, Revision No. 24 provides estimates of precision for coarse aggregate passing 19.0 mm and retained on 4.75 mm. The precision estimate was developed from the results of Proficiency Sample Testing Program conducted by MTO. The published precision statements are based on the analyses of test results from 125 to 157 laboratories that tested 9 pairs of coarse aggregate proficiency test samples covering a nine year period from 1998 to 2006.

The coefficient of variation in 2007 (28.2%) is noticeably lower than the values (36.5% to 45.2%) reported in the past three years, and the precision estimate (41%) published by MTO. The lower variation may have resulted from the simplified test procedure used. However, the majority of the points (89%) in the scatter diagram are accounted in the lower left and

upper right quadrants indicating pronounced between laboratory operator biases and almost equal variation for each sample. In general, laboratories that reported values in excess of 24% or less than 7% should critically examine their equipment and procedure.

3.4.8 Petrographic Number (Concrete) – Test No. 14

The coarse aggregate examined in 2007 was Beach Gravel from CBM Brighton Pit (MTO MAIDB No. T07-174).

Analysts from twenty-four laboratories examined samples 1.07 and 2.07 (full fraction), and submitted work sheets showing subdivision according to rock type and quality. Laboratories 59, 101, and 203 used the same analyst, as did 13 and 80.

The gravel coarse aggregate contains carbonate rocks derived mainly from the Gull River and Bobcaygeon Formations. Gneiss and granite derived from the Precambrian Grenville geologic subprovince to the north composes a much lesser portion of the sample. Overall the samples contained 90 to 95% good aggregate (approximately 80% hard and or hard to medium hard surface weathered carbonate, 10 to 15% silicate rock). Only two labs, Lab 71 (sample 1.07) and Lab 172 (sample 1.07) reported a good aggregate content below 90%.

In the fair group, shaley or clayey carbonate was the most commonly reported rock type by nineteen of the twenty-four labs tested with a range where reported from 0.1% to 2.6%.

In the poor category, most analysts found trace to small amounts of shaley carbonate. Several observers also found trace amounts of friable sandstone, siltstone, gneiss and granite.

The only deleterious group rock type was trace to small amounts (less than 1.4%) of clay found by eleven of the twenty-four labs.

Most labs performed well in correctly classifying the rock types present. In general the greatest discrepancy was between the proportions of carbonate rock types present especially rock types 1, 2, 20, 35, 41 and 42. Many of the labs with petrographic numbers of 120 and greater generally had included higher amounts of carbonates in the fair category (rock types 35, 41, 42). Discrepancy is also pronounced in the good aggregate category carbonate proportions. Labs 31, 38, 59, 101, and 203 reported no carbonate in the surface weathered carbonate (rock type 20) even though the sample was of gravel. Lab 61 reported nearly half (40-45%) of the good carbonate present in the sample as sandy carbonate (rock type 2). Lab 31 also reported anomalously high values for hard conglomerate-sandstone-arkose (rock type 3).

Analysts from labs 188 and 316 (sample 1.07) and lab 260 (sample 2.07) made calculation errors on the submitted worksheets. These errors are not judged to be overly significant for labs 188 and 260 as the corrected values would decrease the reported petrographic number by only 0.1 (lab 260) and 1.2 (lab 188). Calculation errors made by lab 316 for sample 1.07 resulted in a reported petrographic number 3 points lower than if the errors had not been made. While not a large discrepancy, the corrected petrographic number would place lab 316 outside of one standard deviation from the mean for sample 1.07.

The similar ASTM standard for this test, C-295, does not report a petrographic number and has no precision statement.

3.4.9 Petrographic Analysis (Fine Aggregate)

The fine aggregate examined in 2007 was sand from the Barino Construction pit (MTO MAIDB Number L05-040) North of Longlac.

Analysts representing eight laboratories examined samples 1.07 and 2.07, and submitted work sheets showing subdivision according to rock/mineral type and sieve size. Laboratories 59, 80, 101 and 203 used the same analyst. The material this year was from the Longlac area of northern Ontario and was natural sand with a mixture of carbonate and silicate rocks. There were small amounts of chert (typically leached and lightweight).

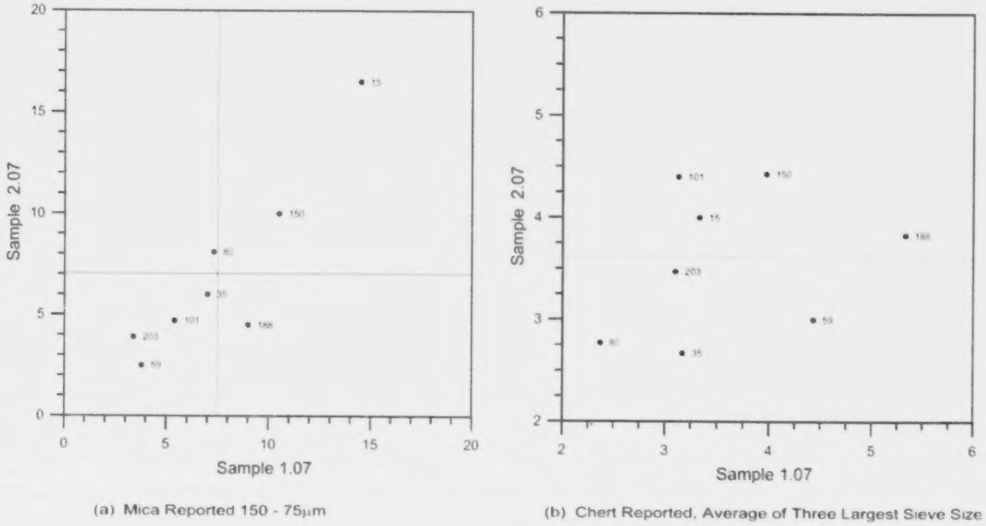


Figure 2. Fine Aggregate Petrographic Examination Scatter Diagrams

All observers recognized the main components: however, there were some differences in measured proportions of the rock types in the samples. Reported mica contents range from 2.5% to 16.5% for the minus 150 um retained 75 um fraction. An average of the chert content for the three largest sieve sizes is much better with a total range of 2.4% to 5.3% between labs. Silicate and mica contents typically increased from larger to smaller sieve sizes while carbonate and chert contents decreased. Lab numbers 150 and 188 reported 0.07 to 2.9% contamination on the three smallest sieve sizes for Sample 1.07. Lab number 188 reported 0.5% contamination on the minus 1.18 mm retained 0.6 mm fraction.

The similar ASTM standard for this test, C-295, has no precision statement.

3.4.10 Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Sixty-three laboratories reported results for this test in 2007. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, one laboratory reported control sample results outside the established range and the lab was excluded from the analysis. Three outliers were rejected using the iterative technique.

The precision statements in the MTO LS-618 was revised in 2007 based on the results of MTO proficiency sample test data gathered over a nine year period since 1998 and published in Revision No. 24. The multi-laboratory coefficient of variation of 5.6% published in the latest revision is for 19.0 mm maximum size aggregate with abrasion losses in the range from 5% to 20%. The mean loss in this year test was 12.3%. The coefficient of variation of 5.5% obtained in 2007 is consistent with the value published in LS-618, and that of the values reported in the past three years (5.0% to 6.5%). The scatter plot for this test shows a combination of random variation and laboratory bias for some laboratories

3.4.11 Freeze-Thaw Loss – Test No. 17

Forty-nine laboratories reported results for this test in 2007. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in control. This information is used to alert the laboratory to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, section 9.1). This year, all the participants have reported control sample results within the established range. Three outliers were selected using the iterative technique.

The precision statements in the MTO LS-614 were revised in 2007 based on the proficiency sample test results collected for a period of nine years from 1998 to 2006. The multi-laboratory coefficient of variation of 21% published in the latest Revision No. 24 is for coarse aggregate passing 19.0 mm and retained on 4.75 mm sieves, with freeze-thaw losses in the range of 5% to 18%. The coefficient of variation obtained in 2007 (20.8%) is consistent with the value, 21%, published in the LS-614, Revision No. 24, and the values reported in the 2004 (21.3%) and 2005 (20.8%) studies. However, the variation is noticeably higher than the value (13.1%) reported in 2006. The scatter diagram shows a combination of random variation and laboratory bias for some laboratories.

The results reported by the outlier laboratories deviate considerably from the mean values. It is likely that there are two main reasons for the wide spread of their data: insufficient damage caused by freezing which may be due to freezing too rapidly or difference in sieving intensity. The laboratories identified as outliers should modify their processes to try and achieve losses closer to the mean loss of the control aggregate. LS-614, Revision 22 (Appendix 1) in the MTO Laboratory Testing Manual gives a procedure for determining and adjusting sieving time for quantitative analysis. It is possible that increased use of this procedure to adjust sieving time is having a positive effect on performance of laboratories in this test.

3.4.12 Sieve Analysis (Fine Aggregate) – Test No. 20-25

Unlike in the past, the material for the sieve analysis of fine aggregate was supplied and the participants were asked to prepare an appropriate quantity of sample as required by the test method. The scatter diagrams, with the exception of 150 µm and 75 µm, show random variation with little laboratory bias. However, the scatter plots for those two sieves show a combination of random variation and laboratory bias for some laboratories. The standard deviations of the fine sieves in 2007, with the exception of Test Nos. 20, 24 and 25, are consistent with that of the values reported in the past three studies, but the variations are noticeably higher than the values published in the ASTM precision statements. However, the multi-laboratory variations obtained for Test Nos. 20, 24, and 25 are consistent with that of the values published in ASTM. As in previous inter-laboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained on the sieve, the more efficient the sieving process and the better the precision. When there is a small amount of material on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

Altogether, eight outlier laboratories were selected using the critical value method. Outlier labs with a very low percent passing the 75 µm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing the sieve. Three outlier labs have reported percent passing the 75 µm sieve in excess of 3%. These labs should inspect their sieves and review of their test procedures.

3.4.13 Relative Density (Fine Aggregate) – Test No. 27 and Absorption (Fine Aggregate) – Test No. 28

Ninety-three laboratories performed these tests in 2007. The ministry has been using the Test Method MTO LS-605 for the determination of bulk relative density and absorption of fine aggregates throughout its correlation studies. MTO LS-605 follows the ASTM C-128, except that it requires the removal of materials finer than 75 µm from the test specimen. The participants in the 2007 program were asked to test Sample 1.07 according to MTO LS-605 and Sample 2.07 in accordance with the procedures described in ASTM C 128. The significant difference between the methods is that Test Method LS-605 requires the test specimens to be prepared in duplicates and washed on the 75 µm sieve until all the material finer than 75 µm is removed. As a consequence, the test results reported were obtained for the same materials with the only difference being the presence or absence of fines passing the 75 µm sieve. The presence of material finer than 75 µm in the test specimens can result in lower densities and higher absorption. This sand was exceptionally clean (mean - 75 µm of 1.6%) but nevertheless, the Sample 2.07 gave higher mean absorption (0.14%) and lower density (0.01). The difference between the standard deviations obtained for Samples 1.07 (MTO) and 2.07 (ASTM) is not significant for both, bulk relative density (0.011 for 1.07 and 0.013 for 2.07) and absorption (0.16 for 1.07 and 0.14 for 2.07).

Ten outliers for Test No. 27 and thirteen outliers for Test No. 28 were selected using the iterative technique. It is imperative that differential drying of the various sized particles be

avoided by *constant* stirring of the sample under the air current during the drying process. As short as 30 seconds periods of rest can be detrimental for the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state. The resulting test observations are lower relative densities and higher absorption values.

The standard deviations obtained in 2007 for both, relative density and absorption of Samples 1.07 and 2.07 are consistent with the values reported in the past three years, using the MTO test procedure. In addition, the multi-laboratory variations obtained in 2007 are noticeably less than that of the values published in the ASTM precision statements.

3.4.14 Magnesium Sulphate Soundness (Fine Aggregate) – Test No. 29

Thirty-two laboratories participated in this test in 2007. No outlier was detected by the use of iterative technique or critical value method. All the data, with the exception of three, are accounted in the lower left (quadrant 3) and upper right (quadrant 1) with the axis of scatter of points at approximately 45 degrees. As in previous years, the scatter diagram shows strong laboratory bias. The coefficient of variation obtained in 2007 (29.8%) is consistent with the values reported in 2006 (28%) but, it is slightly higher than that of the value (22%) obtained in 2005. The ASTM precision statements are for coarse aggregates only, and there is no established estimate for fine aggregates.

3.4.15 Amount of Asphalt Coated Particles in Coarse Aggregate – Test No. 30

Two hundred and four laboratories reported results in 2007. One laboratory was identified as an outlier using the critical value method. The scatter plot shows a combination of random variation and laboratory bias for some laboratories. There was no MTO or ASTM precision estimate in the past to compare, but MTO has established precision statements for this test based on the data gathered from the MTO Proficiency Sample Testing Program over six year period since 2001. The multi-laboratory coefficient of variation of 9.6% published in the MTO LS-621, Revision No. 24 is for 19.0 mm maximum size coarse aggregate mixed with asphalt coated particles in the range of 25% to 45%. The coefficient of variation obtained in 2007 (16%) is noticeably higher than the values (8.3% to 11.8%) reported in the past three years and the value published in the MTO LS-621. Laboratories, which reported values of less than about 20% and above 39%, should critically evaluate their interpretation of the definition and re-examine their samples. There is no comparable or similar ASTM test procedure.

3.4.16 Moisture-Density Relationship (One-Point Method) – Test Nos. 31-33

In the past, the participants were instructed to perform this test on the finer portion of the Granular 'A', i.e., material passing the 4.75 mm sieve, bulk sample supplied for other aggregate tests. In 2007, the laboratories were given a separate Granular 'A' sample processed for this test and asked to perform the test on the sample as received. The test Samples 1.07 and 2.07 were prepared by the participants by splitting the Granular 'A' sample supplied.

There were no precision statements for this test method, in spite of its use in the MTO proficiency sample testing program for almost twenty years. Precision statements based on the results of the MTO proficiency sample testing program have been developed and published in the MTO LS-623, Revision No. 24. Proficiency sample testing data gathered since 1998 for base and sub-base materials (9 pairs of samples) were used for developing the published precision estimates.

One hundred and forty-seven laboratories reported results for this test in 2007. Two outliers for Tests No.31 and three outliers for Test No. 33 were rejected using the critical value method. The variations in 2007 for Test No. 31 and 32 are consistent with that of the values reported in the previous three years, but the value obtained for Test No. 33 is slightly lower than that of the values reported in the past three years. However, the standard deviations obtained for all three parameters, i.e., wet density, dry density, and optimum moisture content, are consistent with the precision estimates published in the LS-623, Revision No. 24.

The majority of the points in the scatter diagrams are located in the lower left and upper right quadrant of the plots with strong laboratory bias showing testing rather than the material variability is the source of the errors. The possible causes for the bias may be operator error and the use of an improper mould even though the participants were requested to use only the 152.4 mm diameter mould. This test also requires significant operator skill to obtain the point within the band in the first attempt. Those laboratories with poor ratings should examine their equipment and procedure to discover the causes for this variation. There is no ASTM precision statement for this test.

3.4.17 Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants in previous studies were asked to prepare their own test sample from the bulk Granular 'A' supplied. In 2007, laboratories were provided with a bulk sand sample and advised to prepare 500g test Samples 1.07 and 2.07, according to the quantities specified in the instruction sheet for a standard grading. Sixty-three laboratories participated in this test in 2007. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. This year, all the laboratories, except one, reported control sample results within the range established for the material. This lab was manually removed from the statistical analysis.

The precision statements of this test method were revised in 2007 based on the MTO Proficiency Sample Testing data collected since 1998. The revised precision estimate is published in LS-619, Revision No. 24. The abrasion losses of the fine aggregates used in the correlation studies from 1998 to 2006 ranged from 7% to 30%. The multi-laboratory coefficient of variation for this test has been found to be 8.7%. Therefore, the results of two properly conducted tests by different laboratories on samples of the same aggregate are not expected to differ by more than 24.6%. The coefficients of variations (6.5% and 4.8%) obtained in 2007 are noticeably lower than the multi-laboratory coefficient of variation (8.7%) published in Revision No. 24. In addition, the coefficients of variations obtained are slightly lower than the range of values (6.8% to 9.0%) obtained in the past three years.

Four outliers were selected by the use of iterative technique. Eighty-seven percent of the data points are located in the lower left and upper right quadrant of the scatter diagram indicating a strong laboratory bias.

3.4.18 Particle Size Analysis of Soil – Test Nos. 40-45

Sixty-six laboratories reported results for the hydrometer test in 2007. Test 40 is reported for information purposes only, because 88% of the participants reported 100% passing 2.00 mm. Outliers were selected using the iterative technique. Participants were requested to perform the test according to MTO LS-702, Revision No.19. To verify that the test procedures were followed, the laboratories were asked to submit the data sheets. Based on the information provided by the participants, all the laboratories did perform the test in accordance with MTO LS-702.

The scatter diagrams for all of the particle sizes show significant laboratory biases. The standard deviations obtained in 2007 for all of the hydrometer tests (No. 41 to 45 are more or less similar to the values reported in the 2004 to 2006 studies. It should be noted that the soil from the same source (Walker Brothers Vineland Quarry) was used in the 2004, 2006 and 2007 proficiency sample testing programs. As a result, the mean values from all three years are almost identical, but the standard deviations obtained for the 20μm size in 2006 and the values obtained for 5μm in 2005 differ by a wide margin from the results of 2007.

The laboratories that are identified as outliers should examine their equipment and procedure very carefully to make certain all is within specification and the procedure is followed exactly.

3.4.19 Atterberg Limits of Soil – Test Nos. 46-48

Seventy-nine laboratories reported results for Atterberg Limit tests in 2007. Three outlier laboratories were identified for liquid and plastic limit tests, using the iterative technique. The scatter plots for both liquid and plastic limits show strong laboratory bias. This variation is characteristic of tests that require significant operator skills, and good condition and calibration of the apparatus. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce the laboratory biases.

The variations obtained for all three tests in 2007, i.e., liquid limit, plastic limit, and plasticity index are slightly lower than that of the values reported in the past three years. The standard deviations obtained for plastic limit and plasticity index are consistent with the values published in the ASTM precision statements. However, the variations obtained for liquid limit test are considerably higher than that of the ASTM value. As previously noted under the hydrometer test, soil from the same source was tested in 2004, 2006 and 2007. The mean values obtained for each of these tests in all three years are almost identical, but the variations obtained in 2007 are slightly lower than that of the values reported in 2004 and 2006.

3.4.20 Specific Gravity of Soils – Test No. 49

Fifty-five laboratories reported results for this test in 2007. The participants were requested to perform the test on a minimum of three specimens in accordance with the procedures described in Section 7.1of MTO LS-705, Revision No. 20. The laboratories were asked to submit the data sheet to verify if the range, i.e., the difference between the largest and smallest value, is within the limit specified (0.02) in the test method. Based on the data sheets, seven laboratories exceeded the limit and were manually deleted from the analysis. Four outliers were also detected using the iterative technique. Ninety-one percent of the plots are located in 1st and 3rd quadrants of the scatter diagram showing a strong laboratory bias. Several steps in this test procedure can influence the results. Particularly, the equipment and method employed for preparation of test specimen as well as for removal of air entrapped in the pycnometer or flask. The possible cause for the bias may be because the laboratories do not fully comply with the test procedures. Laboratories finding themselves in this situation should examine their equipment and procedure very carefully.

The test method MTO LS-705 is similar to that of AASHTO T 100, which reports a multi-laboratory standard deviation of 0.04. As in the past three studies, the standard deviations obtained in 2007 are lower than that of the precision estimate published in the AASHTO T 100. The mean and standard deviations obtained in 2007 are very similar to that of the values obtained in 2004 and 2006 where the material from the same source was tested.

3.5 SUPERPAVE CONSENSUS PROPERTY TESTS

3.5.1 Uncompacted Void Content (FA) – Test No. 95

The participants were asked to perform the test in accordance with the Test Method MTO LS-629, using the sand sample supplied. This test method is a modified version of AASHTO T 304 and was developed for the purposes of determining compliance with Superpave consensus properties. MTO LS-629 follows the Method A of AASHTO T 304, except for the preparation of the test specimen to be used in the determination of bulk specific gravity of fine aggregates. The significant difference between the methods is that MTO LS-629 requires the test specimens be washed on the 75 µm sieve until all the material finer than 75 µm is removed. In addition, LS-629 specifies that the bulk relative density is determined using the graded sample and not the individual size fraction method described in Clause 9.4 of T 304. Further, the participants were advised to compute the uncompacted void contents of Sample 1.07 and 2.07 using the bulk relative densities reported for Test No. 27, i.e., the densities determined according to MTO LS-605 and ASTM C 128, respectively.

It should be noted that the same test procedure was used in 2007 and 2006 programs. The sand sample supplied for the 2007 program consisted of only 1.6% material finer than 75 µm compared to 7.8% in the fine aggregate tested in 2006. The difference between the mean uncompacted void contents obtained in 2007 (41.3% and 41.2%) is small compared with the 2006 study (43.1% and 42.1%) where, there was a substantial difference in the fine contents of the materials tested.

Fifty-seven laboratories submitted results for this test in 2007. Three laboratories were identified as outliers using the iterative technique. The scatter diagram shows a combination of random variation and laboratory bias for some laboratories. The standard deviations obtained in 2007 (0.70 and 0.52) are consistent with the value obtained for Sample 1.06 in 2006, and are almost 0.5 times that of the values obtained in 2004 and 2005. The standard deviations obtained for both samples are noticeably higher than the values published in the ASTM for graded standard sand (0.33%). The estimates of precision in ASTM are based on graded sand as described in ASTM C 778, which is considered rounded and is graded from 600 μm to 150 μm, and may not be typical of the samples that were supplied for this testing program.

ASTM C 1252 suggests that a difference in relative density of 0.05 will change the calculated void content by about one percent. The range of bulk relative densities used for Sample 1.07 is slightly higher than that of the range of values used for 2.07. The difference in the multi-laboratory variation between Sample 1.07 and 2.07 may have resulted from the range of bulk relative density used for the computation. There is marked improvement in the multi-laboratory variation in 2007. The improvement may have resulted from the changes made to MTO LS-605 in Revision No. 23 and the type of material (clean sand) used in 2007. The laboratories that reported lower bulk relative density and uncompacted void content values for Sample 1.07 than that of 2.07 must review their test procedures and the skill of the technician.

It should be noted that adopting the revised procedure where the fine aggregate is washed before determining density will usually give a higher bulk relative density. This in turn will result in higher uncompacted void contents for fine aggregates with significant minus 75 μm fines contents. The impact on fine aggregates with low fines contents will be small since density will not normally change significantly.

3.5.2 Sand Equivalent Value of Fine Aggregate – Test No. 96

The participants were asked to obtain no less than 1500 g of test sample from the fine aggregate sample supplied. The fine aggregate sample supplied in 2007 contained less than 2% of material finer than 75 μm. Two alternate procedures for the preparation of test specimen (air-dry or pre-wet) are allowed in both ASTM and AASHTO Methods. The participants were given the option of preparing the test specimen in accordance with either method.

Fifty-four laboratories participated in this test in 2007. No outlier was identified by the use of critical value method or iterative technique. The lower left and upper right quadrants of the scatter diagram together account for 87% of the points showing significant laboratory bias. The standard deviations obtained in 2007 (3.5 and 3.7) are noticeably lower than the values reported in 2006 (5.8 and 5.9), and the multi-laboratory precision value (4.4) published by ASTM for samples with sand equivalent value greater than 80.

3.5.3 Percent of Fractured Particles in Coarse Aggregate – Test No. 97

The samples supplied did not contain adequate material retained on 19.0 mm sieve. Because

of this, the participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only.

Fifty-eight laboratories submitted results for this test in 2007. Three outliers were detected using the critical value method. The scatter diagram shows a strong laboratory bias. The average mean values obtained by the ASTM (67.4%) method and MTO (66.0%) versions of the test on the same aggregate differ by only 1.4%, but the standard deviations obtained by ASTM (4.1%) is significantly lower than that of MTO version (6.3%). The ASTM test method is very similar to MTO LS-607, but ASTM has not conducted inter-laboratory studies to determine precision and currently publishes statistical data provided by MTO. The variations in 2007 (3.7% and 4.6%) are consistent with the values obtained in 2006 and are lower than that of the value (5.2%) published in ASTM.

3.5.4 Percent Flat and Elongated Particles in Coarse Aggregate – Test No. 99

As for the MTO version of this test described in Section 3.4.7 of this report, the participants were advised to test the processed coarse aggregate sample supplied for this as a single sample, using a ratio of 5:1.

Fifty-six laboratories performed this test in 2007. One outlier was detected using the iterative technique. The standard deviations obtained in 2007 are significantly higher than that of the values reported in the past three years of studies. However, the coefficient of variation of 43.0% in 2007 is lower than the values (50.7% to 64.0%) obtained in the past three years. There is no ASTM precision statement for this test.

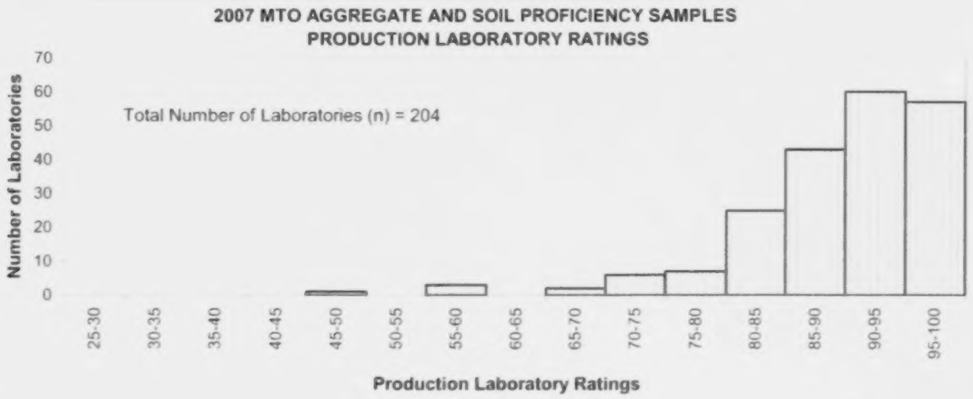
4. Laboratory Rating System

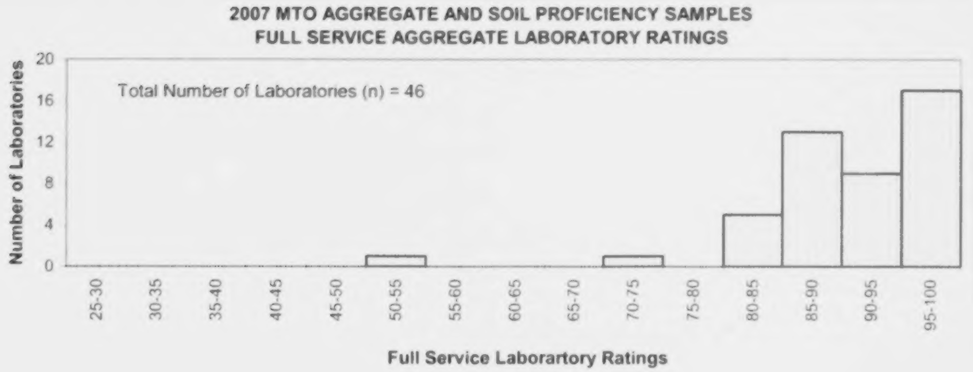
The laboratory rating system assigns separate ratings for low complexity (production) aggregate laboratories, high complexity (full service) aggregate laboratories, and for soil laboratories. Low complexity laboratories are required to carry out wash pass 75 μm, gradation, percent crushed particles, percent asphalt coated particles, and optional, percent flat and elongated particles. In addition to those low complexity tests, high complexity laboratories must carry out micro-Deval (coarse and fine), freeze-thaw and/or magnesium sulphate soundness, relative density and absorption (coarse & fine). Forty-six (46) high complexity (full service) aggregate laboratories participated in the program in 2007. Soil laboratories are required to carry out particle size analysis, Atterberg limits and specific gravity of soil. Fifty-three (53) laboratories participated in all the soil tests, in 2007.

A similar laboratory rating system is also used for assigning laboratory ratings for Superpave aggregate laboratories. The laboratories are required to perform all four tests, i.e., uncompacted void content of fine aggregate, sand equivalent value of fine aggregate, percent fractured particles in coarse aggregate, and flat and elongated particles in coarse aggregate. Fifty-two of the fifty-eight laboratories reported results for all of the consensus property tests.

The rating system gives a maximum of 10 for each test, *e.g.* 5 for wash pass 75 μm on sample 1.07, plus -5 for wash pass 75 μm on sample 2.07, equals 10 (the negative sign indicating a test result less than the mean is ignored). Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), one-point Proctor values (maximum wet and dry density, and optimum moisture content), particle size analysis of soils and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the gradation results, the ratings are modified so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by the number of sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Aggregate, soil, and Superpave laboratory ratings are given in Figures 3 and 4. The laboratory rating system data is reported in the Appendices E1, E2, E3, and E4.

Laboratory ratings are given in the covering letter accompanying this report to individual laboratories. A poor or good rating for a laboratory in one year is an indication of how that laboratory performed in the proficiency study, and may not be a reflection of how the laboratory performs year round. A consistently poor rating over two or more years may be cause for serious concern.





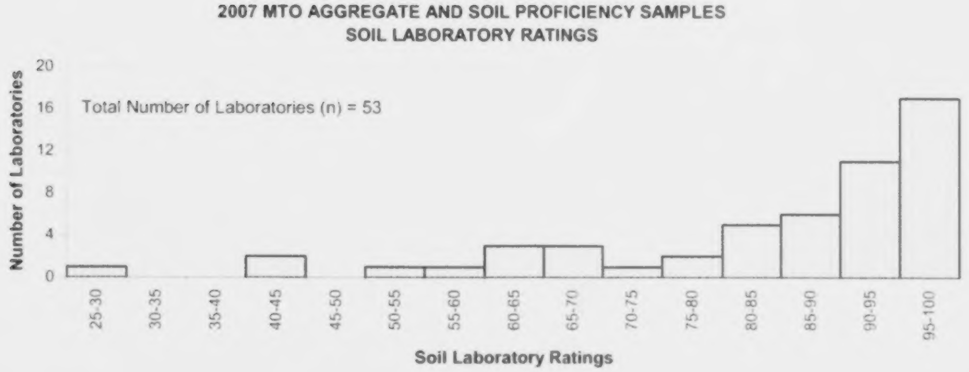


Figure 3. Laboratory Ratings

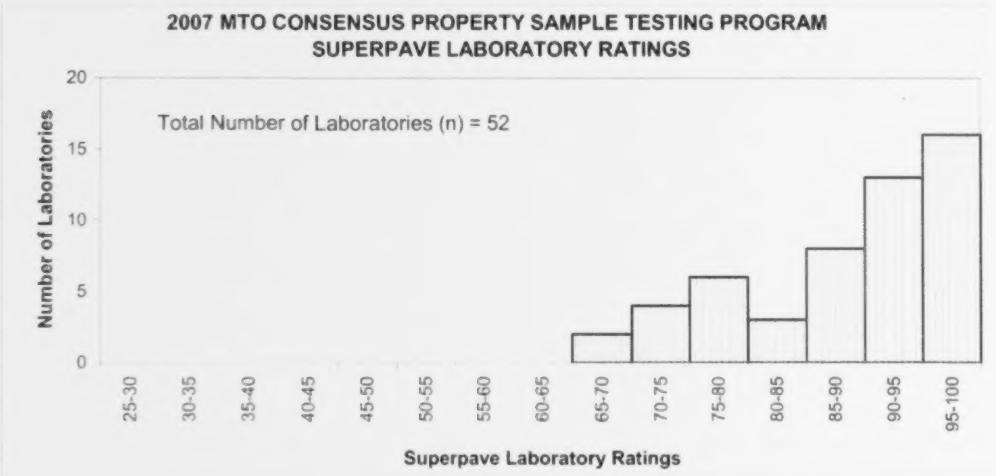


Figure 4. Superpave Laboratory Ratings

5. Conclusions

The method of proficiency sample preparation employed by MTO resulted in no significant (coarse and fine aggregate) mean gradation differences between samples 1.07 and 2.07. The differences in mean as well as in variations between pairs of samples for both coarse and fine sieves are negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform material at reasonable cost.

The majority of the aggregate and soil test results of the 2007 Proficiency Sample Testing Program compare favourably and also in some cases show noticeable improvement over previous years' results. The scatter diagrams for the majority of the aggregate tests show either random variation or a combination of random variation and laboratory bias for some laboratories.

One hundred and ninety-three of the laboratories that participated in the aggregate tests are CCIL Type C (low complexity tests) certified and forty-six of those are certified for high complexity tests (Type D). CCIL inspects the certified laboratories for quality control procedures, ability of technicians, and condition and calibration of the equipment at about eighteen month intervals. The aggregate tests are probably showing general improvement in variation due to the CCIL laboratory inspection, proficiency sample testing, and due to an increased awareness of the importance of proper testing.

The variations found in 2007 for the soil tests are consistent with the values reported in the last three years' studies, but the scatter diagrams still show strong laboratory biases. The results of soil tests are significantly influenced by operator skills, testing environment, and the condition and calibration of the equipment. Thirty-four of the fifty-five laboratories that participated in the soil tests are on the MTO Approved List and participated in the MTO on-site lab inspection program[8], which is voluntary. Most of the laboratories that are on the MTO list were inspected about five to six years ago and few re-inspections have been done to date.

The results of 2007 Superpave Consensus Property Tests show significant improvements in the performance of the laboratories. Further, the multi-laboratory precision, with the exception of uncompacted void content, are noticeably lower than the values published in ASTM precision statements. However, the scatter diagrams show strong laboratory biases. The consensus property tests were introduced in the proficiency sample testing program in 2002 and most of the laboratories that participated in this program have now gained experience in these test procedures. The improvements in the multi laboratory variation of these tests may also likely be due to the inspection program that was introduced by CCIL in 2003.

8 To arrange an inspection of your Soil Laboratory, please contact Mark Vasavithasan, Soils and Aggregates Section, Ministry of Transportation, phone (416) 235 – 4901, fax (416) 235 – 4101.

6. Recommendations

Although, there are noticeable improvements in the multi-laboratory variations, strong laboratory biases still remain in a number of test procedures. The laboratories that were identified as outliers and obtained zero ratings should examine the condition and calibration of equipment, testing procedures, and skills of the technicians. It is good practice to do this whenever a rating of 2 or less is obtained.

The results of the 2007 MTO Aggregate and Soil Proficiency Sample Program suggest that most laboratories have performed satisfactorily. Laboratories that obtained relatively low ratings must focus on operator training, standardization and calibration of equipment, and improvements to laboratory environment in order to improve their performance.

For all of the tests that were included in this study, the equipment to be used is regulated by the test method itself. A good state of maintenance, repair and correct calibration are sometimes lacking. It is hoped that the mandatory Quality System implemented by CCIL will encourage laboratories to conduct self-examination to ensure they have the correct equipment and properly trained technicians. Laboratories will find that a well-documented and regular program of internal inspection, calibration, and testing of control or reference samples, are beneficial to maintaining a high level of confidence in their results.

7. Acknowledgments

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Appendix A: Glossary of Terms

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value.' This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process, and an accepted reference value of the property being measured. For the majority of aggregate and soil tests there is no acceptable reference material, so bias is impossible to compute.

Critical Value is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all the observations did indeed constitute a random sample from a common system of causes.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where:

$$C.V. = \frac{\text{std dev}}{\text{mean}} \times 100$$

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Multi-laboratory precision (one-sigma limit (1s)) is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances the estimates of the one-sigma limit for multi-laboratory precision are usually larger than those for single operator precision because different operators and different equipment are being used in different laboratories.

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s), by the factor $2\sqrt{2}$ (2.83).

Sample mean or average is the sum of all observations divided by the total number of observations.

Median is synonymous with the middle and the **sample median** is the middle value of a list of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the

sample median is the *single middle value* in the ordered list, if n is odd, or the *average of the two middle values* in the ordered list, if n is even, where n equals the number of observations.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified as an outlier it means something went wrong either with the sample or in the laboratory.

Appendix B1: List of Participants

2007 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this Program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
A. L. Blair Construction Limited Moose Creek, ON Mr. Bryan Blanshard Tel: 613 538-2271	✓	✓				✓								✓				
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AME - Materials Engineering Gormley, ON Mr. Blaine Dobson Tel: 905 640-7772	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	
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AME - Materials Engineering (24-270) Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-271) Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-272) Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-297) Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-298) Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-911) Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-912) Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AMEC Earth & Environmental Ltd Scarborough, ON Mr. S. Sufi Tel: 416 751-6565	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Hamilton, ON Mr. John Balinski Tel: 905 312-0700	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

2007 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this Program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
AMEC Earth & Environmental Ltd. Orillia, ON Mr. Don Nicol Tel: 705 329-1542	✓	✓				✓	✓							✓	✓			
AMEC Earth & Environmental Ltd. Thorold, ON Mr. Andrew Markov Tel: 905 687-6616	✓	✓				✓								✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Cambridge, ON Mr. Lou Maier Tel: 519 653-3570	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
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Bertrand Construction L'Original, ON Mr. Philippe Arnold Tel: 613 675-4614	✓	✓				✓	✓				✓	✓		✓				
BOT Construction Oakville, ON Mr. Sella Vicks Tel: 905 827-3250	✓	✓				✓								✓	✓			
Bruno's Contracting (Thunder Bay) Ltd. Thunder Bay, ON Mr. John Lowes Tel: 807 623-1855	✓	✓				✓								✓				
C. Villeneuve Construction Hearst, ON Mr. Charles Harris Tel: 705 372-1838	✓	✓		✓		✓	✓							✓	✓			
C.T. Soil & Materials Testing Inc. Windsor, ON Mr. Thomas O'Dwyer Tel: 519 966-8863	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Caledon Sand & Gravel Ltd. Caledon, ON Mr. Dean Glenn Tel: 519 927-5224	✓	✓				✓	✓							✓				
Capital Paving Inc. Guelph, ON Mr. Mark Latyn Tel: 519 822-4511	✓	✓				✓	✓							✓	✓			
CBM Aggregates - Aberfoyle Aberfoyle, ON Mr. Leigh Mugford Tel: 519 824-8169	✓	✓				✓	✓							✓				
CBM Aggregates – Brighton Brighton, ON Mr. Leigh Mugford Tel: 613 475-2420	✓	✓				✓								✓				
CBM Aggregates – Cambridge Cambridge, ON Mr. Leigh Mugford Tel: 519 740-3053	✓	✓				✓	✓							✓				
CBM Aggregates – Limehouse Limehouse, ON Mr. Leigh Mugford Tel: 416 806-3590	✓	✓				✓	✓							✓				
CBM Aggregates – Pinewood Westwood, ON Mr. Leigh Mugford Tel: 705 295-6843	✓	✓			✓	✓	✓			✓	✓	✓		✓				
CBM Leaside Lab Toronto, ON Mr. Stephen Parkes Tel: 416 423-2439	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				

2007 Participants List

Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this Program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

Participant	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
CBM Sunderland Lab Sunderland, ON Mr. Leigh Mugford Tel: 416 862-1382	✓	✓				✓	✓							✓				
Chung & Vander Dollen Engineering Limited, Kitchener, ON Mr. William Evans Tel: 519 742-8979	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
City of Sault Ste Marie Sault Ste Marie, ON Mr. John Sloan Tel: 705 946-9918	✓	✓				✓								✓				
CMT Engineering Inc. St. Clements, ON Mr. Tim salter Tel: 519 699-5775	✓	✓				✓								✓	✓			
COCO Paving Inc. Windsor, ON Mr. Ernie Scerbo Tel: 519 948-7133	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	
COCO Paving Inc. – Mobile No. 1 Windsor, ON Mr. Ernie Scerbo Tel: 519 948-7133	✓	✓				✓	✓							✓	✓			
Concrete Materials Lab, Dept of Engineering, U. Of Toronto Dr. R. D. Hooton Tel: 416 978-5912													✓					
Construction Control Inc. Woodbridge, ON Mr. Anthony Davis Tel: 905 856-1438	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Construction Testing Asphalt Lab Oakville, ON Mr. Peter Lung Tel: 905 469-6352	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Cornwall Gravel Company Limited Cornwall, ON Mr. Bob Mroz Tel: 613 932-6571	✓	✓				✓								✓				
Cox Construction Limited Guelph, ON Mr. Arlaan Warren Tel: 519 824-6570	✓	✓				✓	✓							✓				
Cruickshank Construction Ltd Kingston, ON Mr. Tim Bilton Tel: 613 542-2874	✓	✓				✓								✓				
Cruickshank Construction Ltd Morrisburg, ON Mr. Dan Byvelds Tel: 613 543-2978	✓	✓				✓	✓							✓	✓			
D. Crupi and Sons Limited Toronto, ON Mr. P. Kandasaami Tel: 416 291-1986	✓	✓		✓		✓	✓							✓				
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Davroc Testing Laboratories Inc. Brampton, ON Mr. Sal Fasullo Tel: 905 792-7792	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Markham, ON Mr. Andy Burleigh Tel: 905 940-8383	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

2007 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this Program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
DBA Engineering Limited Mobile 10 Markham, ON Mr. Andy Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			
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DBA Engineering Ltd. Kingston, ON Mr. Mark McClelland Tel: 613 389-1781	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Department of Civil Engineering Ryerson University, Toronto Dr. S. Medhat Tel: 416 979-5000 x 6457													✓					
District Municipality of Muskoka Bracebridge, ON Mr. Dave Wood Tel: 705 645-6764	✓	✓				✓								✓	✓	✓	✓	
Drain Bros Excavating Ltd. Lakefield, ON Mr. Dwaine Drain Tel: 705 639-2301	✓	✓				✓	✓				✓	✓		✓	✓			
DST Consulting Engineers Inc. Kenora, ON Mr. Andrew Brookes Tel: 807 548-2383	✓	✓				✓	✓							✓	✓			
DST Consulting Engineers Inc. Thunder Bay, ON Mr. Scott Tozer Tel: 807 623-2929	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
DST Consulting Engineers Inc. Ottawa, ON Mr. Joel Lajeunesse Tel: 613 748-1415	✓	✓				✓								✓	✓	✓	✓	
Dufferin Aggregates - Aberfoyle Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Acton Milton, ON Mr.Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Blair Pit Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Carden Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Cayuga Cayuga, ON Mr. Maurice Guimont Tel: 905 772-3331	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Dufferin Aggregates - Flamborough Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - London London, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓								✓				

2007 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this Program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Dufferin Aggregates - Milton Milton, ON Mr. Maurice Guimont Tel: 416 798-4772	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓	
Dufferin Aggregates - Mosport Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Putnam Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Construction Limited - Mobile 1 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓				✓	✓							✓	✓			
Dufferin Construction Limited - Mobile 2 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Dufferin Construction Limited - Mobile 3 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓			
Dufferin Construction Ltd. (QC) - Bronte Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Dunn Paving Limited Tecumseh, ON Mr. Marcel Gauvin Tel: 519 727-3838	✓	✓				✓	✓							✓	✓			
E.C. King Contracting Lab #1 Owen Sound, ON Mr. Herb Villneff, Sr. Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Esko Savela & Son Contracting Inc. Thunder Bay, ON. Mr. Esko Savela Tel: 807 983-2097	✓	✓				✓								✓				
Fermar Construction Limited Rexdale, ON. Mr.Di Francescantonio Tel: 416 675-3550	✓	✓		✓		✓	✓							✓	✓			
Fowler Construction Company Bracebridge, ON Mr. James Gordon Tel: 705 645-2214	✓	✓		✓		✓	✓				✓	✓		✓	✓			
G. Tackaberry & Sons Construction Co. Ltd., Athens, ON Mr. Paul Rodgers Tel: 613 924-2634	✓	✓				✓	✓							✓	✓			
Gamsby and Mannerow Limited Owen Sound, ON Mr. Bill Dubeau Tel: 519 376-1805	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Gazzola Paving Ltd. Etobicoke, ON Mr. S. Andualem Tel: 416 675-7007	✓	✓				✓	✓							✓				
Geo Terre Limited Brampton, ON Ms. Brani Vujanovic Tel: 905 455-5666	✓	✓				✓								✓	✓	✓	✓	
Geo-Logic Inc. Peterborough, ON Mr. Wayne Rayfuse Tel: 705 749-3317	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓

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Geo-Logic Inc. Pembroke, ON Ms. Elizabeth Reid Tel: 613 735-8361	✓	✓				✓								✓	✓			
Golder Associates Ltd. London, ON Mr. Chris Sewell Tel: 519 652-0099	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Golder Associates Ltd. Mississauga, ON Ms. Mariana Manojlovic Tel: 905 567-4444	✓	✓				✓								✓	✓	✓	✓	✓
Golder Associates Ltd. Ottawa, ON Ms. Chris Mangione Tel: 613 224-5864	✓	✓		✓	✓	✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Sudbury, ON Ms. Tina Nantel Tel: 705 524-6861	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Whitby, ON Mr. John Watkins Tel: 905 723-2727	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Golder Associates Ltd. Windsor, ON Mr. Roy Walsh Tel: 519 250-3733	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Graham Brothers Construction Limited Brampton, ON Mr. Greg Thompson Tel: 905 453-1200	✓	✓		✓		✓	✓				✓	✓		✓	✓		✓	
Greenwood Aggregates Orangeville, ON Mr. Andrew Raymond Tel: 519 941-0732	✓	✓		✓		✓	✓							✓				
Hard Rock Paving Company Limited Port Colborne, ON Ms. Jennifer Koros Tel: 905 834-4581	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Harold Sutherland Construction Ltd. Kemble, ON Mr. Roland Leigh Tel: 519 376-0603	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Holger Lohse, Consulting Geologist Adjala, ON Mr. Holger Lohse Tel: 519 941-0875								✓	✓									
Huron Construction Lab No. 1 Chatham, ON Mr. Herb Villneff, Sr. Tel: 519 354-0170	✓	✓				✓	✓							✓	✓			
Inspec-sol Inc. Kingston, ON Mr. Joseph Bennett Tel: 613 389-9812	✓	✓				✓								✓				
Inspec-Sol Inc. Mississauga, ON Mr. Karl Roechner Tel: 905 712-4771	✓	✓				✓								✓	✓	✓	✓	
Intratech Engineering Laboratories Inc. Scarborough, ON Mr. Frank Miles Tel: 416 754-2077	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
J & P Leveque Bros. Haulage Ltd. Bancroft, ON Mr. Shawn Fransky Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	

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J & P Leveque Bros. Ltd. - Mobile 1 Bancroft, ON Mr. Shawn Fransky Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	
Jacques Whitford Limited Ottawa, ON Mr. Brian Prevost Tel: 613 738-0708	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Jacques Whitford Limited Markham, ON Mr. Iqbal Patel Tel: 905 474-7700	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
John D. Paterson & Associates Nepean, ON Mr. Christian Pelletier Tel: 613 226-7381	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
John D. Patterson & Associates North Bay, ON Mr. Shawn Nelson Tel: 707 472-5331	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
John Emery Geotechnical Engineering Ltd. Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
John Emery Geotechnical Engineering - Mobile 4, Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓				✓	✓							✓	✓			
K. J. Beamish Construction - Mobile 1 King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓				✓	✓							✓	✓			
K. J. Beamish Construction - Mobile 2 Hanmer, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓				✓	✓							✓	✓			
K.J. Beamish Construction King City, ON Mr. Chad Henderson Tel: 905 833-4666	✓	✓		✓		✓	✓	✓			✓	✓		✓	✓		✓	
Karson Kartage & Konstruction Stittsville, ON Mr. Cam MacDonald Tel: 613 831-0717	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
Lafarge Canada Montreal, QUE. Ms. M. de Grosbois Tel: 514 738-1202													✓					
Lafarge Canada - Brechin Plant Brechin, ON Ms. Christine Crumbie Tel: 705 484-5225	✓	✓		✓		✓	✓				✓	✓		✓				
Lafarge Canada - Coldwater Plant Cold Water, ON Ms. Christine Crumbie Tel: 705 484-5225	✓	✓				✓	✓							✓				
Lafarge Canada - Mosport Lab Orono, ON Mr. Peter Hill Tel: 905 983-9260	✓	✓				✓	✓							✓				
Lafarge Canada - Orillia Lab Brechin, ON Ms. Christine Crumbie Tel: 705 686-7262	✓	✓				✓	✓							✓				
Lafarge Canada Inc - Dundas Quarry Dundas, ON Mr. Paul Lum Tel: 905 527-3671	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓			

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Lafarge Canada Inc. Stouffville, ON Mr. Dave Clark Tel: 905 640-7092	✓	✓		✓		✓	✓							✓	✓			
Lafarge Canada Inc. – Brockville Brockville, ON Mr. Paul Arkeveld Tel: 613 342-0262	✓	✓				✓	✓			✓				✓				
Lafarge Canada Inc. - Caledon Caledon, ON Mr. John Kroeze Tel: 519 927-1113	✓	✓				✓	✓							✓				
Lafarge Canada Inc. - Fonthill Fonthill, ON Mr. Jim Vingerhoets Tel: 905 892-2686	✓	✓				✓								✓				
Lafarge Canada Inc. - Hamilton Hamilton, ON Mr. Chris Thomas Tel: 905 522-7735	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓			✓	
Lafarge Canada Inc. - McAdoo Brockville, ON Mr. Paul Arkeveld Tel: 613 342-0262	✓	✓				✓	✓							✓				
Lafarge Canada Inc. - Meldrum Meldrum Bay, ON Mr. Jeff Middleton Tel: 705 283-3011	✓	✓				✓	✓							✓				
Lafarge Canada Inc. - Ottawa Ottawa, ON Mr. Fred Douglas Tel: 613 837-4223	✓	✓				✓	✓				✓	✓		✓				
Lafarge Paving & Construction Toronto, ON Mr. Andrew Pahalan Tel: 416 633-9670	✓	✓		✓		✓	✓							✓				
Lafarge Paving & Construction (Eastern) Ltd., Belleville, ON Mr. Gary Bates Tel: 613 962-2461	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	
Lafarge Paving & Construction (Eastern) Ltd., Nepean, ON Mr. Brad Gooderham Tel: 613 829-1770	✓	✓		✓		✓	✓				✓	✓		✓				
Lavis Contracting Co. Limited Clinton, ON Mr. Allan Gardner Tel: 519 482-3694	✓	✓		✓		✓								✓	✓			
Law Engineering (London) Inc. London, ON Mr. Joe Law Tel: 519 680-9991	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Leo Alarie and Sons Ltd. - Mobile 10060 Timmins, ON Mr. Jan Luthe Tel: 705 268-2106	✓	✓				✓	✓							✓				
M. J. Labelle Co. Limited - Mobile 1 Cochrane, ON Mr. Peter Osmar Tel: 705 272-4201	✓	✓				✓								✓	✓			
M. J. Labelle Co. Limited - Mobile 2 Cochrane, ON Mr. Peter Osmar Tel: 705 272-4201	✓	✓				✓								✓	✓			
M. R. Wright & Associates Sault Ste. Marie, ON Mr. Daren Stadnisky Tel: 705 945-5091	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	

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McAsphalt Engineering Services Toronto, ON Mr. Keith Davidson Tel: 416 281-8181	✓	✓		✓		✓	✓							✓	✓			
Merlex Engineering Limited North Bay, ON Mr. Jake P. Duhaime Tel: 705 476-2550	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Mill-Am Corporation - Mobile 890901 Oldcastle, ON Mr. H. Villneff, Sr. Tel: 519 945-7441	✓	✓		✓		✓	✓							✓	✓			
Miller Northwest - Mobile 1 Dryden, ON Mr. H. Villneff, Sr. Tel: 807 223-2844	✓	✓				✓	✓							✓	✓			
Miller Northwest - Mobile 87526 Dryden, ON Mr. H. Villneff, Sr. Tel: 807 223-2844	✓	✓				✓	✓							✓				
Miller Paving Limited - Carden Mobile Markham, ON Mr. Narayan HanasogeTel: 905 475-6660	✓	✓				✓	✓							✓				
Miller Paving Limited - Carden Quarry Markham, ON Mr. Narayan HanasogeTel: 905 475-6660	✓	✓				✓	✓							✓				
Miller Paving Limited - Markham Markham, ON Mr. Narayan HanasogeTel: 905 475-6660	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Miller Paving Limited - Mobile 8661 North Bay, ON Mr. Herb Villneff, Sr. Tel: 705 472-3312	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Limited - Whitby Markham, ON Mr. Narayan HanasogeTel: 905 475-6660	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Northern - Mobile 1084 North Bay, ON Mr. Herb Villneff, Sr. Tel: 705 267-1107	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Northern - Mobile 1254 New Liskeard, ON Mr. Herb Villneff, Sr. Tel: 705 647-4331	✓	✓				✓	✓							✓	✓			
Miller Paving Northern - Mobile 60889 New Liskeard, ON Mr. Herb Villneff, Sr. Tel: 705 647-4331	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Northern - Mobile 60900 North Bay, ON Mr. Herb Villneff, Sr. Tel: 705 267-1107	✓	✓		✓		✓	✓							✓	✓			
Ministry of Transportation Downsview, ON Mr. Chris Rogers Tel: 416 235-3734	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
MNA Engineering Limited Scarborough, ON Mr. Peter Balendran Tel: 416 757-8882	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
National Testing Laboratories Limited Winnipeg, Manitoba Mr. Don Flatt Tel: 204 488-6999	✓	✓	✓	✓	✓	✓					✓	✓		✓	✓	✓	✓	

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Naylor Engineering Associates Limited Kitchener, ON Ms. Anne Allen Tel: 519 741-1313	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Naylor Engineering Associates Limited Branford, ON Mr. Tom Staple Tel: 519 720-0078	✓	✓				✓	✓							✓	✓	✓	✓	
Naylor Engineering Associates Limited Stratford, ON Mr. Dennis Kelly Tel: 519 271-0101	✓	✓				✓								✓	✓	✓	✓	
Nelson Aggregate Co. Beamsville, ON Mr. Terry Scambato Tel: 905 563-8226	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Burlington, ON Mr. Steve Drew Tel: 905 335-5251	✓	✓				✓	✓							✓				
Peto MacCallum Limited Barrie, ON Mr. Turney Lee-Bun Tel: 705 734-3900	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Limited Brampton, ON Mr. Geoffrey Uwimana Tel: 905 796-3650	✓	✓		✓		✓	✓							✓	✓			
Peto MacCallum Limited Hamilton, ON Mr. Everett L. Truax Tel: 905 561-2231	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Peto MacCallum Limited Kitchener, ON Mr. Tony Smith Tel: 519 893-7500	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Peto MacCallum Limited Toronto, ON Mr. Geoffrey Uwimana Tel: 416 785-5110	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Pioneer Construction Inc. Sault Ste. Marie, ON Ms. Shelley Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Pioneer Construction Inc. Sudbury, ON Mr. David Pilkey Tel: 705 560-7200	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓
Pioneer Construction Inc. - Mobile 1 Sudbury, ON Mr. David Pilkey Tel: 705 560-7200	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. - Mobile 2 Sudbury, ON Mr. David Pilkey Tel: 705 560-7200	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. - Mobile 3 Sault Ste. Marie, ON Ms. Shelley Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. - Mobile B4/C4 Sault Ste. Marie, ON Ms. Shelley Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓							✓	✓			
Pioneer Construction Inc. - Mobile C 1 Sault Ste. Marie, ON Ms. Shelley Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			

2007 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this Program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Pioneer Construction Inc. - Mobile C 2 Sault Ste. Marie, ON Ms. Shelley Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. - Thunder Bay Sault Ste. Marie, ON Ms. Shelley Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓							✓	✓			
Precision Age Aggregate Testing Ltd. Thunder Bay, ON Mr. Bill Werbowetski Tel: 807 577-3927								✓	✓									
Preston Sand & Gravel Kitchener, ON Mr. Matthew Bell Tel: 519 579-1248	✓	✓				✓	✓							✓				
R. W. Tomlinson Limited Gloucester, ON Mr. Bert Hendriks Tel: 613 822-1867	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	✓
R. W. Tomlinson Limited –Mobile No. 1 Gloucester, ON Mr. Bert Hendriks Tel: 613 822-1867	✓	✓				✓								✓				
R.S Wilson Materials Testing & Inspection Sault Ste. Marie, ON Mr. Robert Wilson Tel: 705 759-2881	✓	✓				✓								✓	✓			
Regional Municipality of Durham Whitby, ON Mr. Joeman Ng Tel: 905 655-3344	✓	✓				✓	✓							✓	✓			
Sarafinchin Associates Limited Rexdale, ON Mr. Scott Jeffrey Tel: 416 674-1770	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Shaba Testing Services Limited Chaput Hughes, ON Mr. Lad Shaba Tel: 705 567-4187	✓	✓				✓	✓							✓	✓			
Shaheen & Peaker Limited Toronto, ON Mr. Andrew Mendonca Tel: 416 213-1255	✓	✓				✓	✓							✓	✓	✓	✓	✓
Shaheen & Peaker Limited (Geo-Canada) Markham, ON Mr. Scott Peaker Tel: 905 474-9255	✓	✓				✓									✓	✓	✓	✓
Shaheen Peaker Thompson Limited Oshawa ON Mr. Dave Thompson Tel: 905 436-9028	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
Site Investigation Services, Division of Jagger Hims Ltd, Peterborough, ON Mr. Steve Ash Tel: 705 743-6850	✓	✓				✓								✓	✓		✓	
Smelter Bay Aggregates Inc. Thessalon, ON Mr. Charles Hernden Tel: 705 842-3908	✓	✓				✓	✓							✓				
Smith's Construction - Mobile 50612 Arnprior, ON Mr. Frank Gainer Tel: 613 623-3144	✓	✓		✓		✓	✓							✓	✓			
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2007 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this Program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
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Soil Engineers Limited Scarborough, ON Mr. S. Sanjeevan Tel: 416 754-8515	✔	✔				✔	✔							✔	✔	✔	✔	✔
St Lawrence Testing & Inspection Co. Ltd Cornwall, ON Mr. Gib McIntee Tel: 613 938-2521	✔	✔		✔		✔	✔			✔	✔	✔		✔	✔	✔	✔	✔
Steed and Evans Limited Heidelberg, ON Mr. Richard Marco Tel: 519 699-4646	✔	✔				✔	✔							✔				
Sutcliffe Rody Quesnel Limited Timmins, ON Mr. Dan Cook Tel: 705 268-4351	✔	✔				✔	✔							✔	✔			
Teranorth Construction & Engineering Limited, Sudbury, ON Mr. James Bot Tel: 705 523-1540	✔	✔				✔	✔							✔	✔			
Terraprobe Testing Limited Brampton, ON Ms. Valerie Rose Tel: 905 796-2650	✔	✔		✔		✔	✔	✔						✔	✔	✔	✔	✔
Terraprobe Testing Limited Barrie, ON Mr. Brian Jackson Tel: 705 739-8355	✔	✔		✔		✔	✔							✔	✔	✔	✔	✔
Terraprobe Testing Limited Stoney Creek, ON Mr. Gerry Muckle Tel: 905 643-7560	✔	✔		✔		✔	✔			✔	✔	✔		✔	✔	✔	✔	
Terraprobe Testing Limited Sudbury, ON Mr. Tommi Leinala Tel: 705 670-0460	✔	✔				✔								✔	✔	✔	✔	✔
Terraspec Engineering Peterborough, ON Mr. Shane Galloway Tel: 705 743-7880	✔	✔				✔	✔							✔	✔	✔	✔	✔
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Thurber Engineering Limited Oakville, ON Dr. P. K. Chatterji Tel: 905 829-8666	✔	✔				✔								✔	✔	✔	✔	✔
Trow Associates Inc. Brampton, ON Mr. Kevin Wells Tel: 905 793-9800	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

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Trow Associates Inc. Stoney Creek, ON Mr. Cam Douglas Tel: 905 664-3300	✔	✔				✔								✔	✔	✔	✔	
Trow Associates Inc. Sudbury, ON Mr. Rob Ferguson Tel: 705 674-9681	✔	✔		✔		✔	✔			✔	✔	✔		✔	✔	✔	✔	✔
Trow Associates Inc. Ottawa, ON Mr. Ismail M. Taki Tel: 613 225-9940	✔	✔		✔	✔	✔	✔	✔		✔	✔	✔		✔	✔	✔	✔	✔
Trow Associates Inc. Thunder Bay, ON Mr. Ken Mosley Tel: 807 623-9495	✔	✔		✔		✔	✔			✔	✔	✔		✔	✔		✔	
Trow Associates Inc. Barrie, ON Mr. Leigh Knegt Tel: 705 734-6222	✔	✔				✔	✔							✔	✔	✔	✔	
Vicdom Sand and Gravel Limited Uxbridge, ON Mr. Bruno Giordano Tel: 905 649-2193	✔	✔				✔	✔							✔				
Walker Aggregates Inc. Thorold, ON Mr. Tom Risi Tel: 905 680-3750	✔	✔		✔		✔	✔				✔	✔		✔				
Walker Aggregates Inc. - Duntroon Collingwood, ON Mr. Tom Risi Tel: 705 445-2300	✔	✔		✔		✔	✔				✔	✔		✔				

Appendix B2: List of Participants

2007 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
AME -Materials Engineering Brampton, ON Mr. Blaine Dobson Tel: 905 640-7772	✓	✓	✓	✓
AME -Materials Engineering Brampton, ON Mr. Scott Crowley Tel: 905 840-5914	✓	✓	✓	✓
AMEC Earth & Environmental Limited Hamilton, ON Mr. John Balinski Tel: 905 312-0700	✓	✓	✓	✓
AMEC Earth & Environmental Limited Scarborough, ON Mr. S. Sufi Tel: 416 751-6565	✓	✓	✓	✓
C. Villeneuve Construction Hearst, ON Mr. Charles Harris Tel: 705 372-1838	✓	✓	✓	✓
Construction Testing Asphalt Lab Oakville, ON Mr. Peter Lung Tel: 905 469-6352	✓	✓	✓	✓
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Dufferin Construction Ltd. - Mobile 1 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓	✓	✓
Dufferin Construction Ltd. - Mobile 3 Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓	✓	✓
Dufferin Construction Ltd. (QC) - Bronte Oakville, ON Mr. Waqas Syed Tel: 905 827-5750	✓	✓	✓	✓
Fermar Construction Limited Rexdale, ON Mr. Walter Di FrancescantonioTel: 416 675-3550	✓	✓	✓	✓
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Geo-Logic Inc. Peterborough, ON Mr. Wayne Rayfuse Tel: 705 749-3317	✓	✓	✓	✓
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Golder Associates Limited Sudbury, ON Ms. Tina Nantel Tel: 705 524-6861	✓	✓	✓	✓

2007 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Golder Associates Limited Whitby, ON Mr. John Watkins Tel: 905 723-2727	✓	✓	✓	✓
Graham Bros. Construction Limited Brampton, ON Mr. Greg Thompson Tel: 905 453-1200	✓	✓	✓	✓
Hard Rock Paving Company Limited Port Colborne, ON Ms. Jennifer Koros Tel: 905 834-4581	✓	✓	✓	✓
Harold Sutherland Construction Limited Kemble, ON Mr. Roland Leigh Tel: 519 376-0603	✓	✓	✓	
Jacques Whitford Limited Ottawa, ON Mr. Brian Prevost Tel: 613 738-0708	✓	✓	✓	✓
John D. Patterson & Associates North Bay, ON Mr. Shawn Nelson Tel: 705 472-5331	✓	✓	✓	✓
John Emery Geotechnical Engineering Ltd Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓	✓	✓
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Karson Kartage & Konstruction Stittsville, ON Mr. Cameron MacDonald Tel: 613 831-0717	✓	✓	✓	✓
Lafarge Canada Inc. – Dundas Quarry Dundas, ON Mr. Paul Lum Tel: 905 527-3671	✓		✓	✓
Lafarge Canada Inc. - Hamilton Hamilton, ON Mr. Chris Thomas Tel: 905 522-7735	✓		✓	✓
Lafarge Paving & Construction (Eastern) Limited Belleville, ON Mr. Gary Bates Tel: 613 962-2461	✓	✓	✓	✓
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Miller Paving Limited - Markham Markham, ON Mr. Narayan Hanasoge Tel: 905 475-6660	✓	✓	✓	✓
Miller Paving Northern - Mobile 1084 North Bay, ON Mr. Herb Villneff, Sr. Tel: 705 267-1107	✓	✓	✓	✓
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2007 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
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Peto MacCallum Limited Toronto, ON Mr. Geoffrey Uwimana Tel: 416 785-5110	✓	✓	✓	✓
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R. W. Tomlinson Limited – Mobile No. 1 Gloucester, ON Mr. Bert Hendriks Tel: 613 822-1867			✓	
Smiths Construction - Mobile 50612 Arnprior, ON Mr. Frank Gainer Tel: 519 482-3694	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd Cornwall, ON Mr. Gib McIntee Tel: 613 938-2521	✓	✓	✓	✓
Steed and Evans Ltd. Heidelberg, ON Mr. Richard Marco Tel: 519 699-4646	✓		✓	✓
Terraprobe Testing Limited Brampton, ON Ms. Valerie Rose Tel: 905 796-2650	✓	✓	✓	✓
The Miller Group Materials Research Lab Markham, ON Mr. Narayan Hanasoge Tel: 905 475-6660	✓	✓	✓	✓
Thunder Bay Testing and Engineering Ltd. Thunder Bay, ON Mr. Tim Fummerton Tel: 807 624-5162	✓	✓	✓	✓
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Trow Associates Inc. Nepean, ON Mr. Ismail Taki Tel: 613 225-9940	✓	✓	✓	✓
Trow Associates Inc. Sudbury, ON Mr. Rob Ferguson Tel: 705 674-9681	✓	✓	✓	✓
Vicdom Sand and Gravel Limited Uxbridge, ON Mr. Bruno Giordano Tel: 905 649-2193				✓

Appendix C: Multi-Laboratory Precision

Test 1	2004		2005		2006		2007		ASTM C117
WP 75 µm	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	1.01	1.03	1.18	1.16	1.36	1.46	0.80	0.80	<1.5
1S	0.15	0.13	0.23	0.26	0.27	0.28	0.17	0.15	0.22
D2S	0.43	0.37	0.65	0.73	0.77	0.81	0.47	0.42	0.62
n/Outliers	197/6		192/12		200/8		199/6		

Test 2	2004		2005		2006		2007		ASTM C136[A]
P 19.0 mm	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	97.7	97.6	92.8	91.8	95.6	95.6	93.8	92.8	95 - 85
1S	0.5	0.6	1.1	1.1	0.8	0.7	1.4	1.7	1.37
D2S	1.5	1.8	3.1	3.2	2.4	2.1	4.0	4.9	3.9
n/Outliers	203/1		206/0		208/0		203/2		

Test 3	2004		2005		2006		2007		ASTM C136[A]
P 16.0 mm	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	89.5	89.0	84.6	82.9	88.2	88.1	77.7	74.6	80 - 60
1S	1.3	1.4	1.3	1.4	1.1	0.9	2.0	3.4	2.82
D2S	3.6	3.9	3.6	4.1	3.2	2.5	5.6	9.7	8.0
n/Outliers	203/1		204/2		200/8		203/2		

Test 4	2004		2005		2006		2007		ASTM C136[A]
P 13.2 mm	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	79.8	78.9	77.5	75.4	81.5	81.3	60.8	57.1	60 - 20
1S	1.8	2.1	1.4	1.5	1.3	1.0	2.4	4.1	1.97
D2S	5.2	5.9	4.1	4.1	3.6	2.8	6.8	11.6	5.6
n/Outliers	203/1		204/2		207/1		202/3		

Test 5	2004		2005		2006		2007		ASTM C136[A]
P 9.5 mm	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	64.8	63.6	66.2	63.8	70.5	70.5	33.3	30.9	60 – 20
1S	2.0	2.5	1.5	1.6	1.4	1.1	2.2	3.1	1.97
D2S	5.6	7.1	4.2	4.4	4.0	3.2	6.2	8.8	5.6
n/Outliers	201/3		204/2		205/3		200/5		

Test 6	2004		2005		2006		2007		ASTM C136[A]
P 4.75 mm	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	47.5	46.6	49.9	47.8	55.5	55.5	4.5	4.3	5 – 2
1S	1.9	2.4	1.4	1.6	1.3	1.0	0.6	0.7	1.04
D2S	5.5	6.7	3.9	4.4	3.6	2.8	1.7	1.9	3.0
n/Outliers	203/1		203/3		204/4		200/5		

Test 8	2004		2005		2006		2007		ASTM C131	
L. L. A	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	C of V	σ'
Mean	21.54	21.27	23.44	23.19	18.47	18.15	23.4	23.5	10-45	23.5
1S	0.91	1.45	1.08	1.41	1.51	1.94	0.71	1.12	4.5%	1.05
D2S	2.57	4.09	3.05	3.97	4.26	5.50	2.00	3.18	12.7%	3.00
n/Outliers	9/2		11/0		10/0		9/1			

A – AMRL reports percent passing inch series equivalent sieves

σ' - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 9 RD (O.D)	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	ASTM C127
Mean	2.687	2.686	2.660	2.660	2.669	2.669	2.683	2.684	
1S	0.006	0.006	0.007	0.009	0.005	0.006	0.007	0.006	0.013
D2S	0.017	0.017	0.020	0.025	0.014	0.017	0.020	0.017	0.038
n/Outliers	89/6		92/5		91/10		90/6		

Test 10 ABS	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	ASTM C127 - 88
Mean	0.463	0.470	1.544	1.549	1.840	1.835	0.497	0.494	< 2%
1S	0.064	0.073	0.143	0.167	0.093	0.081	0.066	0.079	0.145
D2S	0.181	0.206	0.403	0.471	0.263	0.229	0.187	0.223	0.41
n/Outliers	91/4		93/4		92/9		95/1		

Test 11 MgSO4	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	ASTM C88 C of V	σ'
Mean	5.4	5.2	13.6	13.5	7.5	7.5	3.3	3.2	9-20%	3.2
1S	2.0	1.7	3.4	3.0	2.2	2.1	1.1	1.0	25%	0.8
D2S	5.7	4.7	9.5	8.4	6.4	5.9	3.1	2.8	71%	2.3
n/Outliers	34/1		31/1		36/1		36/1			

Test 12 % Crush	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	MTO Workshop
Mean	69.2	69.7	68.7	69.1	74.3	74.2	65.2	66.8	50 - 75
1S	4.7	4.9	5.3	5.6	4.2	4.3	6.4	6.2	6.0%
D2S	13.5	13.9	14.8	15.8	11.8	12.3	18.1	17.7	16.9%
n/Outliers	188/15		201/3		196/12		201/4		

Test 13 % F & E	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	MTO LS - 608 C of V	σ
Mean	9.2	8.9	6.5	6.2	9.7	8.9	15.3	15.5		15.4
1S	3.7	3.5	3.0	2.7	3.4	3.5	4.4	4.3	41%	6.3
D2S	10.5	9.9	8.5	7.8	9.7	10.0	12.4	12.2	116%	17.8
n/Outliers	160/7		162/6		163/6		164/2			

Test 14 PN Conc.	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	ASTM
Mean	150.9	145.3	Analysis		122.7	120.9	113.6	112.7	No ASTM
1S	6.9	12.3	Not		7.9	7.7	5.7	6.7	Standard for this
D2S	19.6	34.9	Done		22.3	21.8	16.0	19.1	Test.
n/Outliers	20/6				25/0		23/1		

Test 16 MDA. CA	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	MTO LS - 618 C of V	σ
Mean	10.53	10.53	11.49	11.43	5.6	5.4	12.2	12.4	5-20%	12.3
1S	0.53	0.53	0.61	0.72	0.38	0.35	0.70	0.66	5.6%	0.69
D2S	1.51	1.51	1.73	2.04	1.08	0.98	1.99	1.88	15.8%	1.95
n/Outliers	58/4		61/4		58/3		60/3			

Test 17 Freeze-thaw	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	MTO LS - 614 C of V	σ
Mean	17.46	17.65	14.59	14.77	12.68	13.22	4.53	4.28	5-18%	4.40
1S	3.72	3.77	2.95	3.16	1.38	2.00	1.00	0.85	21%	0.92
D2S	10.53	10.68	8.31	8.92	3.91	5.67	2.82	2.40	59%	2.62
n/Outliers	47/1		47/3		44/4		46/3			

A – AMRL reports percent passing inch series equivalent sieves.

σ' - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 20	2004		2005		2006		2007		ASTM C136[A]
P 2.36 mm	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	37.2	36.4	37.4	36.2	45.4	45.3	92.9	93.0	95 - 60
1S	1.9	2.1	1.7	1.8	1.7	1.6	0.9	0.7	0.77
D2S	5.6	5.8	4.9	5.0	4.8	4.5	2.6	1.9	2.2
n/Outliers	202/2		205/1		202/6		201/4		

Test 21	2004		2005		2006		2007		ASTM C136[A]
P 1.18 mm	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	28.4	27.9	25.7	25.0	36.5	36.5	68.1	68.4	95 - 60
1S	1.9	2.0	1.5	1.7	2.1	1.9	1.9	1.7	0.77
D2S	5.3	5.6	4.3	4.9	5.9	5.5	5.5	4.7	2.2
n/Outliers	202/2		205/1		206/2		202/3		

Test 22	2004		2005		2006		2007		ASTM C136[A]
P 600 μm	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	19.7	19.4	17.0	16.6	28.2	28.2	33.2	33.5	60 - 20
1S	1.5	1.7	1.1	1.3	1.8	1.9	2.1	1.9	1.41
D2S	4.3	4.9	3.2	3.7	5.2	5.3	6.0	5.4	4.0
n/Outliers	203/1		204/2		207/1		203/2		

Test 23	2004		2005		2006		2007		ASTM C136[A]
P 300 μm	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	12.2	12.0	11.9	11.6	19.0	19.1	9.5	9.4	10 - 2
1S	1.1	1.2	0.8	0.9	1.3	1.4	1.1	0.7	0.65
D2S	3.0	3.5	2.4	2.7	3.6	3.9	3.2	2.1	1.80
n/Outliers	204/0		204/2		207/1		197/8		

Test 24	2004		2005		2006		2007		ASTM C136[A]
P 150 μm	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	8.3	8.1	9.4	9.2	12.0	12.2	2.7	2.6	10 - 2
1S	0.7	0.9	0.7	0.7	0.8	0.8	0.4	0.4	0.65
D2S	2.1	2.6	1.9	1.9	2.3	2.4	1.2	1.0	1.80
n/Outliers	203/1		202/4		205/3		202/3		

Test 25	2004		2005		2006		2007		ASTM C136[A]
P 75 μm	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	6.3	6.1	7.8	7.6	7.7	7.8	1.7	1.6	2 – 0
1S	0.6	0.7	0.6	0.6	0.6	0.6	0.3	0.3	0.31
D2S	1.7	2.1	1.7	1.7	1.6	1.6	0.9	0.9	0.9
n/Outliers	202/2		203/3		202/6		199/6		

Test 27	2004		2005		2006		2007		ASTM C 128
RD (O.D)	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	2.602	2.600	2.593	2.501	2.665	2.615	2.611	2.601	
1S	0.015	0.019	0.017	0.045	0.015	0.038	0.011	0.013	0.023
D2S	0.042	0.054	0.048	0.127	0.042	0.107	0.031	0.037	0.066
n/Outliers	82/11		87/8		90/10		83/10		

Test 28	2004		2005		2006		2007		ASTM C 128
ABS	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean	1.717	1.719	1.713	3.109	0.746	1.502	1.849	1.993	< 1.0%
1S	0.19	0.30	0.30	0.78	0.13	0.49	0.16	0.14	0.23
D2S	0.56	0.85	0.86	2.20	0.37	1.38	0.46	0.39	0.66
n/Outliers	83/10		91/4		88/12		80/13		

A – AMRL reports percent passing inch series equivalent sieves

σ - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 29 MgSO4	2004 3.04	4.04	2005 3.05	4.05	2006 3.06	4.06	2007 1.07	2.07	ASTM C88
Mean	11.9	11.9	17.3	17.0	11.7	11.7	14.8	15.3	ASTM precision
1S	4.5	4.5	3.6	3.9	3.4	3.2	4.7	4.3	Statements for
D2S	12.9	12.9	10.0	10.9	9.6	9.0	13.2	12.2	Coarse
n/Outliers	33/0		29/2		31/0		32/0		Aggregate only

Test 30 % ACP	2004 1.04	2.04	2005 1.05	2.05	2006 1.06	2.06	2007 1.07	2.07	MTO LS-621 C of V	σ
Mean	41.3	40.6	39.4	40.1	39.7	39.9	29.5	29.4	25-45%	29.5
1S	4.9	4.4	3.6	3.1	4.7	4.7	4.8	4.7	9.6%	2.8
D2S	14.0	12.6	10.2	8.8	13.2	13.3	13.7	13.3	27.0%	8.0
n/Outliers	196/6		188/14		206/1		203/1			

Test 31 MWD	2004 3.04	4.04	2005 3.05	4.05	2006 3.06	4.06	2007 1.07	2.07	MTO LS-623
Mean	2.280	2.281	2.308	2.306	2.271	2.272	2.382	2.385	
1S	0.029	0.041	0.037	0.040	0.031	0.030	0.039	0.032	0.030
D2S	0.082	0.116	0.104	0.112	0.088	0.085	0.110	0.090	0.085
n/Outliers	133/8		143/4		147/4		145/2		

Test 32 MDD	2004 3.04	4.04	2005 3.05	4.05	2006 3.06	4.06	2007 1.07	2.07	MTO LS-623
Mean	2.102	2.105	2.134	2.133	2.093	2.095	2.223	2.226	
1S	0.033	0.040	0.045	0.051	0.038	0.041	0.035	0.034	0.033
D2S	0.093	0.113	0.127	0.144	0.107	0.116	0.099	0.096	0.093
n/Outliers	136/5		147/0		149/2		147/0		

Test 33 OMC	2004 3.04	4.04	2005 3.05	4.05	2006 3.06	4.06	2007 1.07	2.07	MTO LS-623
Mean	8.47	8.48	8.16	8.20	8.55	8.48	7.37	7.34	
1S	0.45	0.49	0.47	0.52	0.50	0.61	0.32	0.32	0.41
D2S	1.28	1.39	1.33	1.46	1.41	1.72	0.90	0.90	1.15
n/Outliers	141/0		144/3		147/4		144/3		

Test 34 MDA, FA3	2004 3.04	4.04	2005 3.05	4.05	2006 3.06	4.06	2007 1.07	2.07	MTO LS-619 C of V	σ
Mean	16.6	16.7	15.3	15.4	11.6	11.7	16.8	16.7	7-30%	16.7
1S	1.5	1.4	1.1	1.1	0.9	0.8	1.1	0.8	8.7%	1.4
D2S	4.1	4.1	2.3	3.1	2.7	2.4	3.1	2.4	24.6%	4.1
n/Outliers	61/1		62/3		60/2		58/5			

Test 40 P 2.0 mm	2004 5.04	6.04	2005 5.05	6.05	2006 5.06	6.06	2007 5.07	6.07	MTO LS-702
Mean	100.0	100.0	99.9	99.9	100.0	99.9	99.9	99.9	No MTO
1S									precision
D2S									statements for
n/Outliers	67/0		67/0		68/0				this test

Test 41 P 425 µm	2004 5.04	6.04	2005 5.05	6.05	2006 5.06	6.06	2007 5.07	6.07	MTO LS-702
Mean	97.1	97.0	96.5	96.5	96.9	96.9	97.0	97.1	No MTO
1S	0.6	0.6	0.3	0.4	0.5	0.5	0.6	0.5	precision
D2S	1.7	1.7	1.0	1.1	1.6	1.4	1.6	1.5	statements for
n/Outliers	60/7		59/8		61/7		61/5		this test

A – AMRL reports percent passing inch series equivalent sieves.

σ* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 42	2004		2005		2006		2007		MTO LS-702
P 75 µm	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	91.7	91.7	88.7	88.8	91.7	91.5	91.6	91.7	No MTO
1S	0.9	0.8	0.6	0.5	0.8	0.8	0.8	0.8	precision
D2S	2.7	2.4	1.6	1.5	2.3	2.2	2.3	2.2	statements for
n/Outliers	59/8		63/4		60/8		62/4		this test

Test 43	2004		2005		2006		2007		MTO LS-702
P 20 µm	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	78.1	78.5	71.0	70.3	78.1	78.9	78.7	78.7	No MTO
1S	3.3	3.8	4.8	4.1	6.0	4.5	3.5	4.1	precision
D2S	9.5	10.8	13.6	11.6	17.1	12.8	9.8	11.5	statements for
n/Outliers	60/7		65/2		61/7		63/3		this test

Test 44	2004		2005		2006		2007		MTO LS-702
P 5 µm	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	59.0	58.8	44.0	43.8	59.2	58.9	59.2	59.4	No MTO
1S	4.3	3.8	3.7	3.3	2.7	2.9	2.8	3.2	precision
D2S	12.1	10.7	10.6	9.3	7.8	8.1	8.0	9.1	statements for
n/Outliers	62/5		64/3		58/10		60/6		this test

Test 45	2004		2005		2006		2007		MTO LS-702
P 2 µm	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	44.4	44.6	30.5	30.5	44.4	44.6	44.0	44.6	No MTO
1S	2.8	2.7	3.1	3.0	3.1	3.1	3.4	3.3	precision
D2S	7.9	7.7	8.8	8.6	8.9	8.8	9.7	9.5	statements for
n/Outliers	57/10		65/2		61/7		63/3		this test

Test 46	2004		2005		2006		2007		ASTM D 4318
L. L	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	36.9	37.2	27.7	27.6	37.1	36.9	37.0	37.2	33.3
1S	1.8	1.7	1.4	1.5	1.9	1.9	1.6	1.5	0.8
D2S	5.0	4.9	4.0	4.1	5.3	5.4	4.5	4.2	2
n/Outliers	75/2		73/4		77/1		76/3		

Test 47	2004		2005		2006		2007		ASTM D 4318
P. L	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	19.3	19.2	15.6	15.5	19.2	19.0	18.9	19.1	19.9
1S	1.4	1.4	1.3	1.5	1.6	1.6	1.3	0.9	1.3
D2S	3.9	4.0	3.7	4.4	4.4	4.4	3.8	2.7	4
n/Outliers	74/3		75/2		74/4		77/2		

Test 48	2004		2005		2006		2007		ASTM D 4318
P. I	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	17.5	18.0	12.3	12.3	17.9	18.0	18.1	18.1	13.4
1S	2.1	2.3	1.7	1.8	1.7	1.9	1.3	1.4	1.6
D2S	6.1	6.4	4.7	5.2	4.7	5.6	3.8	4.0	4
n/Outliers	76/1		77/0		75/3		70/9		

Test 49	2004		2005		2006		2007		AASHTO T 100
SG of Soils	5.04	6.04	5.05	6.05	5.06	6.06	5.07	6.07	
Mean	2.729	2.733	2.729	2.728	2.733	2.730	2.731	2.732	
1S	0.029	0.029	0.027	0.030	0.030	0.031	0.027	0.026	0.04
D2S	0.082	0.082	0.076	0.085	0.085	0.088	0.076	0.074	0.11
n/Outliers	50/10		52/6		52/4		44/11		

A – AMRL reports percent passing inch series equivalent sieves.

σ' - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 95	2004		2005		2006		2007		ASTM C 1252
UC Void	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean 1S D2S n/Outliers	42.09 1.48 4.19 35/6	41.81 1.11 3.15	41.19 1.45 4.08 50/1	40.33 1.39 3.91	43.13 0.68 1.93 50/5	42.06 1.08 3.06	41.32 0.70 1.97 54/3	41.21 0.52 1.48	ASTM C 1252[A] 0.33% 0.93%

Test 96	2004		2005		2006		2007		ASTM D 2419
SE Value	3.04	4.04	3.05	4.05	3.06	4.06	1.07	2.07	
Mean 1S D2S n/Outliers	49.9 8.08 22.88 38/0	50.6 8.60 24.30	30.7 3.74 10.54 42/7	30.0 2.82 7.95	56.4 5.76 16.3 53/0	55.9 5.91 16.72	90.6 3.49 9.89 54/0	90.8 3.75 10.63	> 80 4.4 12.5

Test 97	2004		2005		2006		2007		ASTM D 5821
% Fractured	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean 1S D2S n/Outliers	71.18 5.02 14.20 42/0	71.51 5.01 14.18	71.28 5.02 14.17 53/0	70.54 5.24 14.77	75.7 3.9 11.21 54/3	76.1 4.7 13.31	67.0 3.7 10.4 54/4	67.8 4.6 12.9	76.0% 5.2% 14.7%

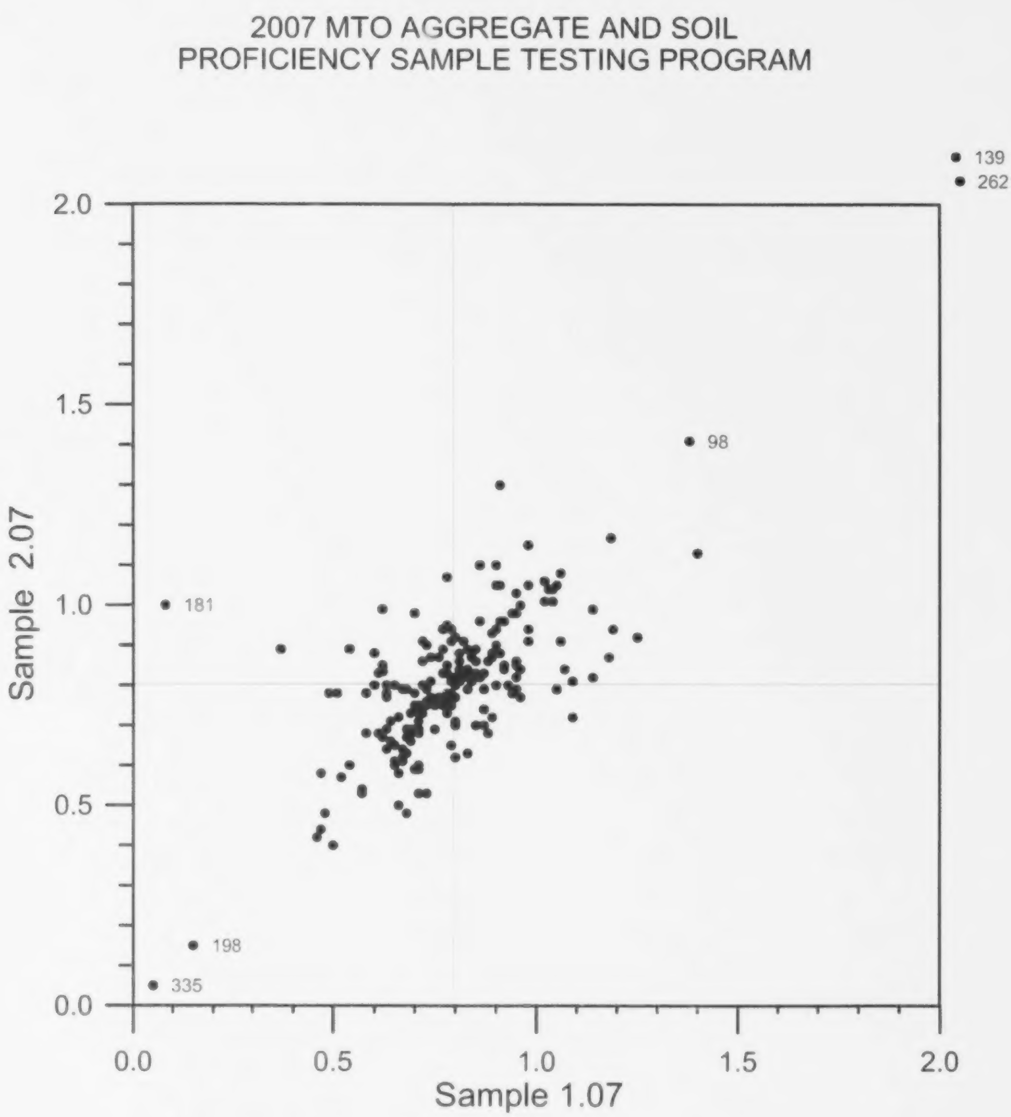
Test 99	2004		2005		2006		2007		AST D 4791
% F & E	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean 1S D2S n/Outliers	1.75 1.12 3.13 40/2	1.61 0.93 2.64	1.14 0.69 1.94 46/7	1.18 0.67 1.89	2.68 1.36 3.86 55/1	2.25 1.16 3.27	4.42 1.86 5.27 55/2	4.53 1.99 5.63	No ASTM precision statements for this test

Test 123	2004		2005		2006		2007		ASTM C 1260
Mortar Bar	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean 1S D2S n/Outliers	0.196 0.035 0.099 16/0	0.410 0.051 0.144	Not Conducted		Not Conducted		Not Conducted		Expansion>0.1% 15.2% 43 %

A – AMRL reports percent passing inch series equivalent sieves.

σ' - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix D1: Scatter Diagrams

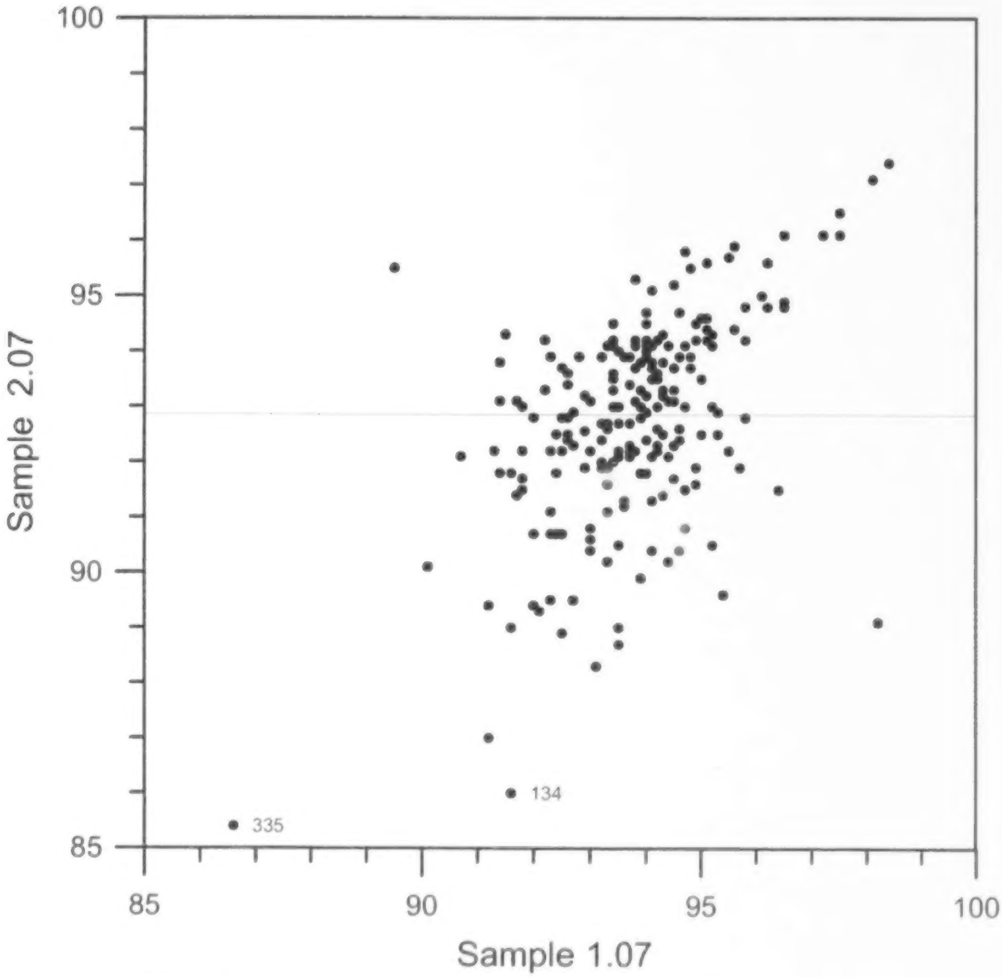


Test 1: Wash Pass 75 um

	Mat 1	Mat 2
Mean	0.798	0.805
Median	0.885	0.850
Std Dev	0.166	0.147
n = 199		

Labs Eliminated: 98; 139; 181; 198; 262; 335

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

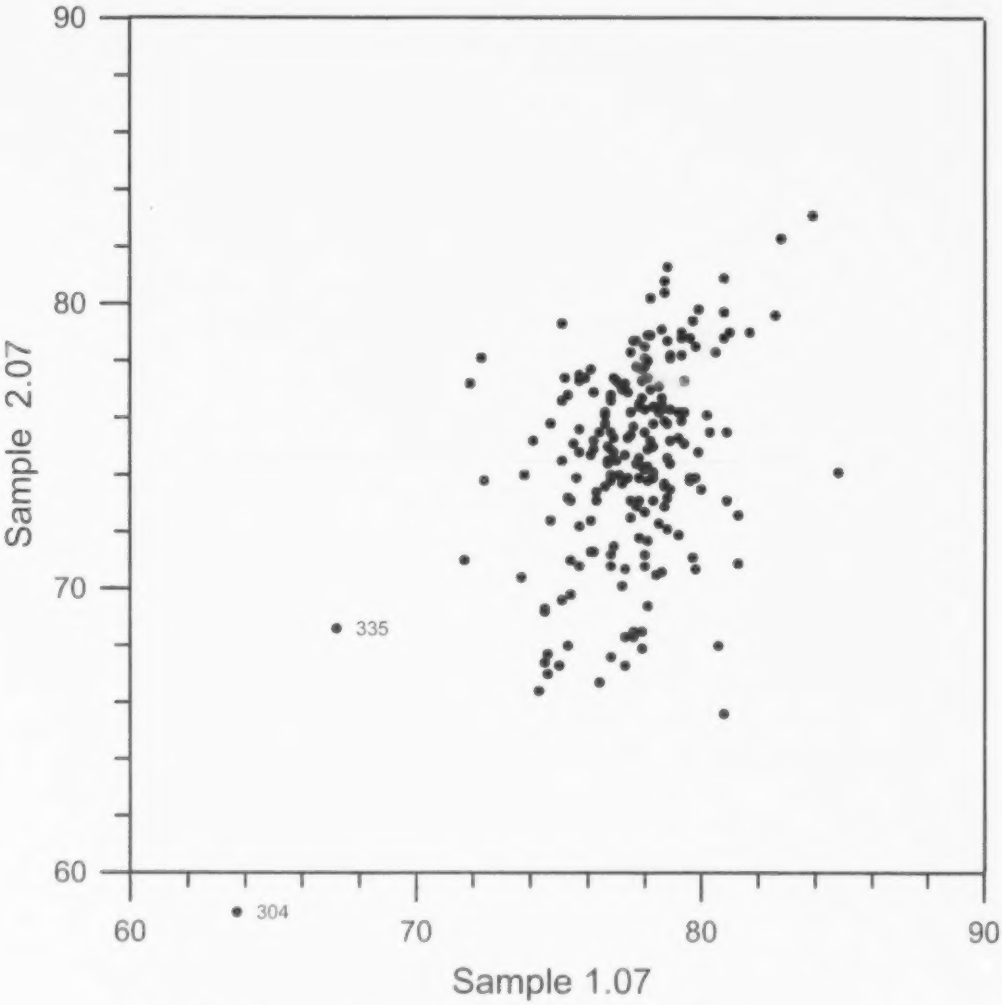


Test 2: Percent Passing the 19.0 mm Sieve

	Mat 1	Mat 2
Mean	93.812	92.810
Median	93.950	92.200
Std Dev	1.428	1.730
n = 203		

Lab Eliminated: 134; 335

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

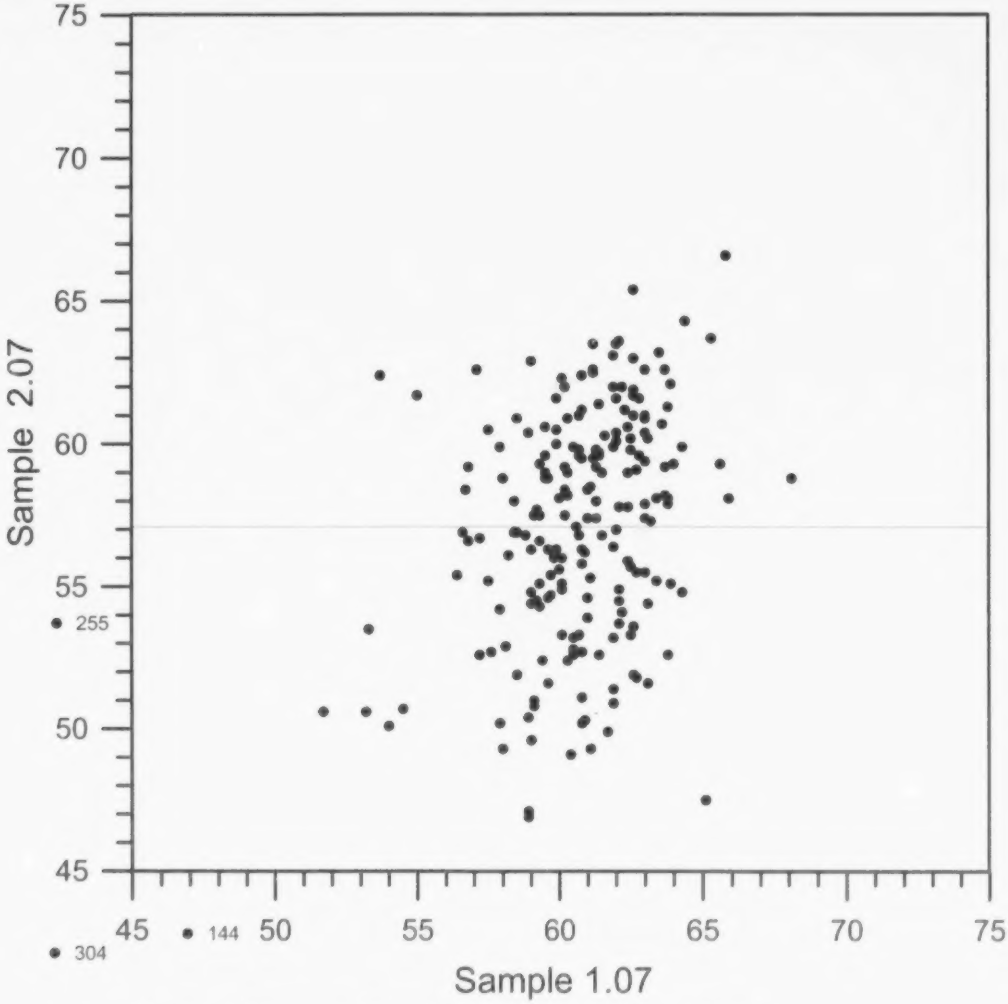


Test 3: Percent Passing the 16.0 mm Sieve

	Mat 1	Mat 2
Mean	77.674	74.643
Median	78.250	74.350
Std Dev	1.984	3.426
n = 203		

Lab Eliminated: 304; 335

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

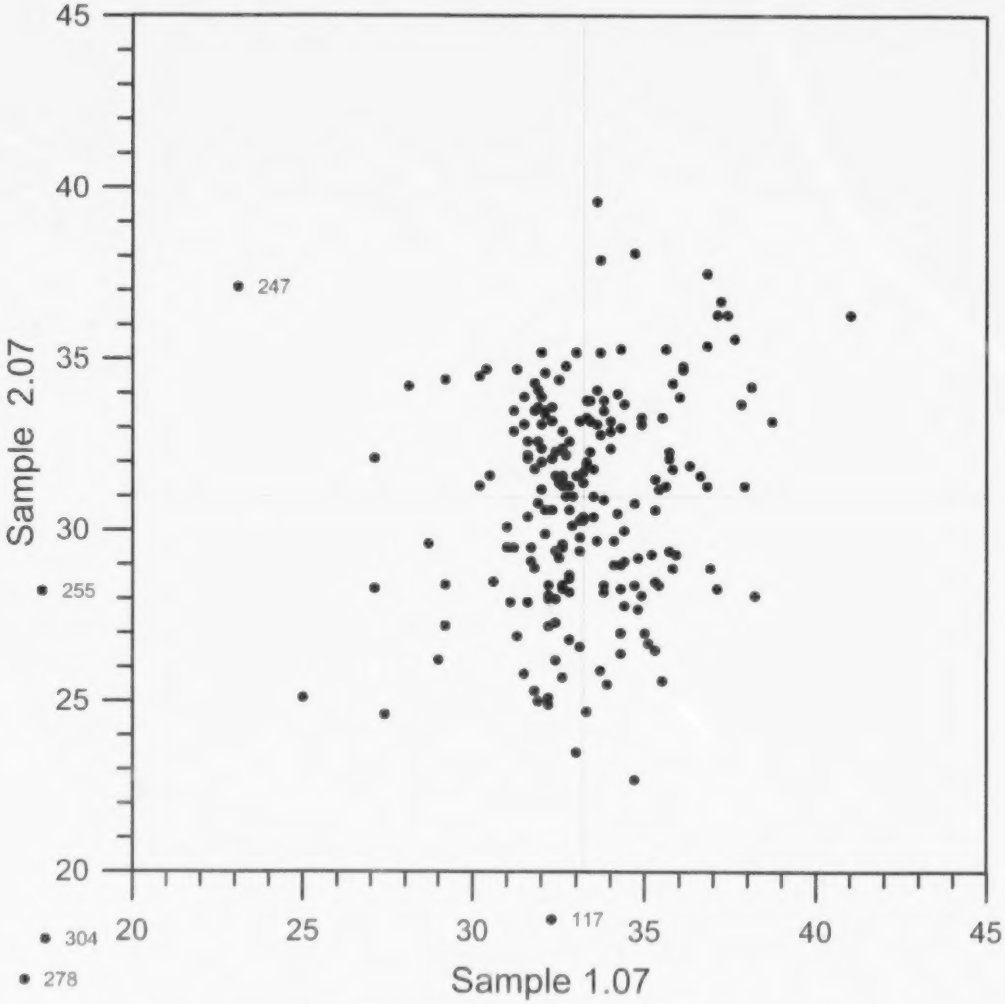


Test 4: Percent Passing the 13.20 mm Sieve

	Mat 1	Mat 2
Mean	60.770	57.078
Median	59.900	56.750
Std Dev	2.420	4.104
n = 202		

Lab Eliminated: 144; 255; 304

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

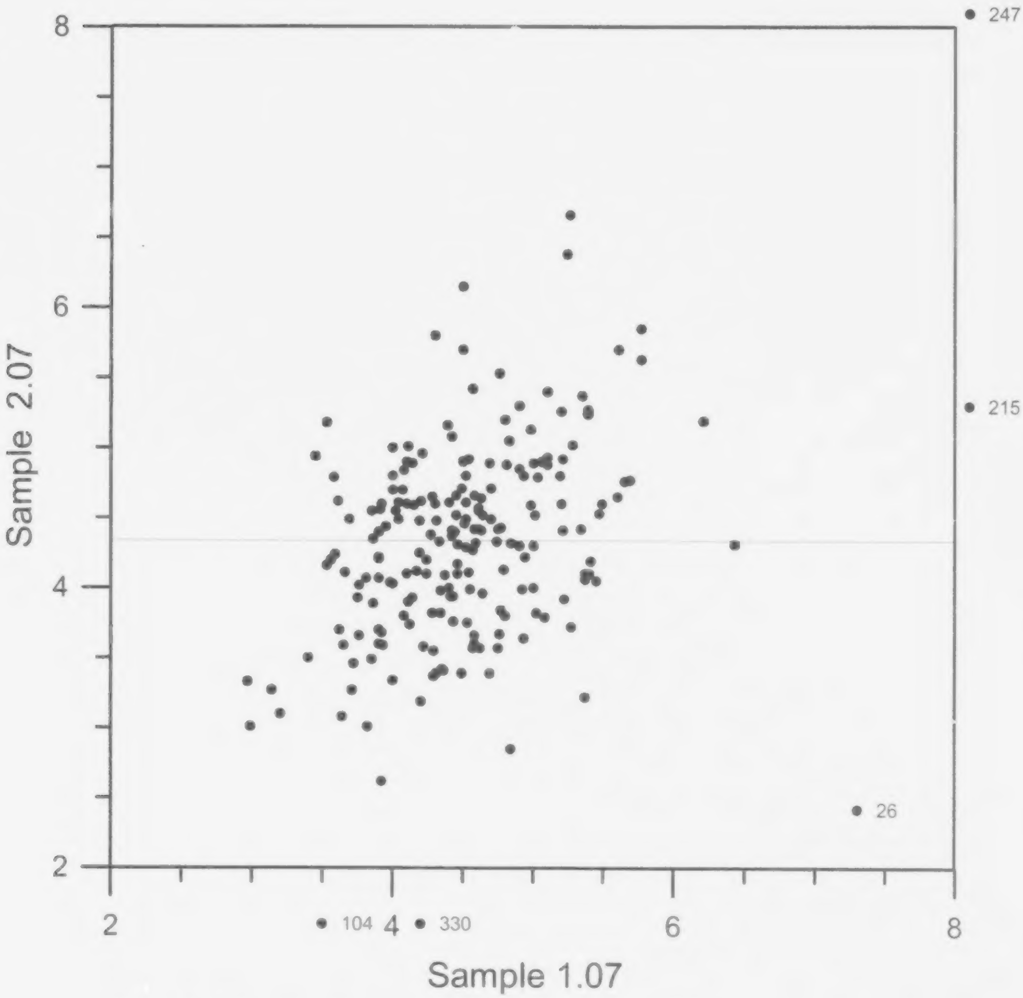


Test 5: Percent Passing the 9.5 mm Sieve

	Mat 1	Mat 2
Mean	33.274	30.958
Median	33.000	31.150
Std Dev	2.193	3.106
n = 200		

Labs Eliminated: 117; 247; 255; 278; 304

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

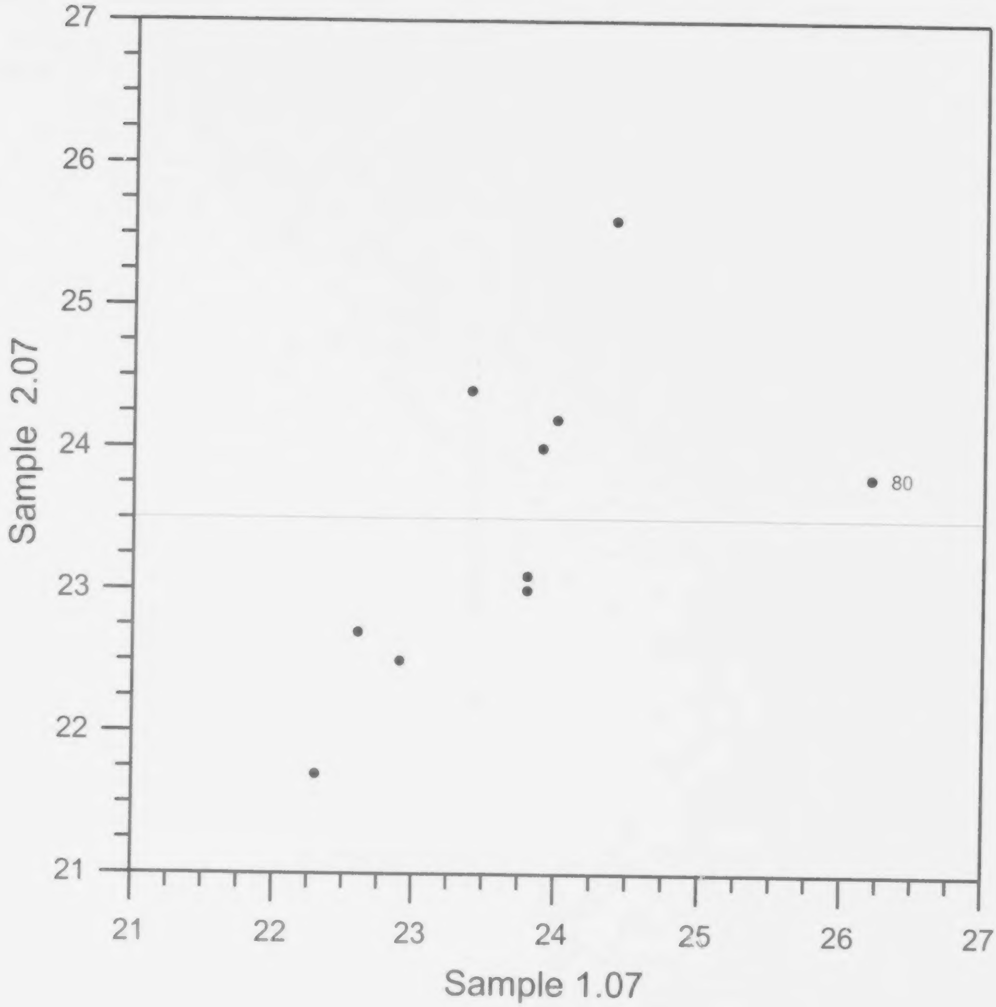


Test 6: Percent Passing the 4.75 mm Sieve

	Mat 1	Mat 2
Mean	4.484	4.337
Median	4.700	4.640
Std Dev	0.598	0.678
n = 200		

Lab Eliminated: 26; 104; 215; 247; 330

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

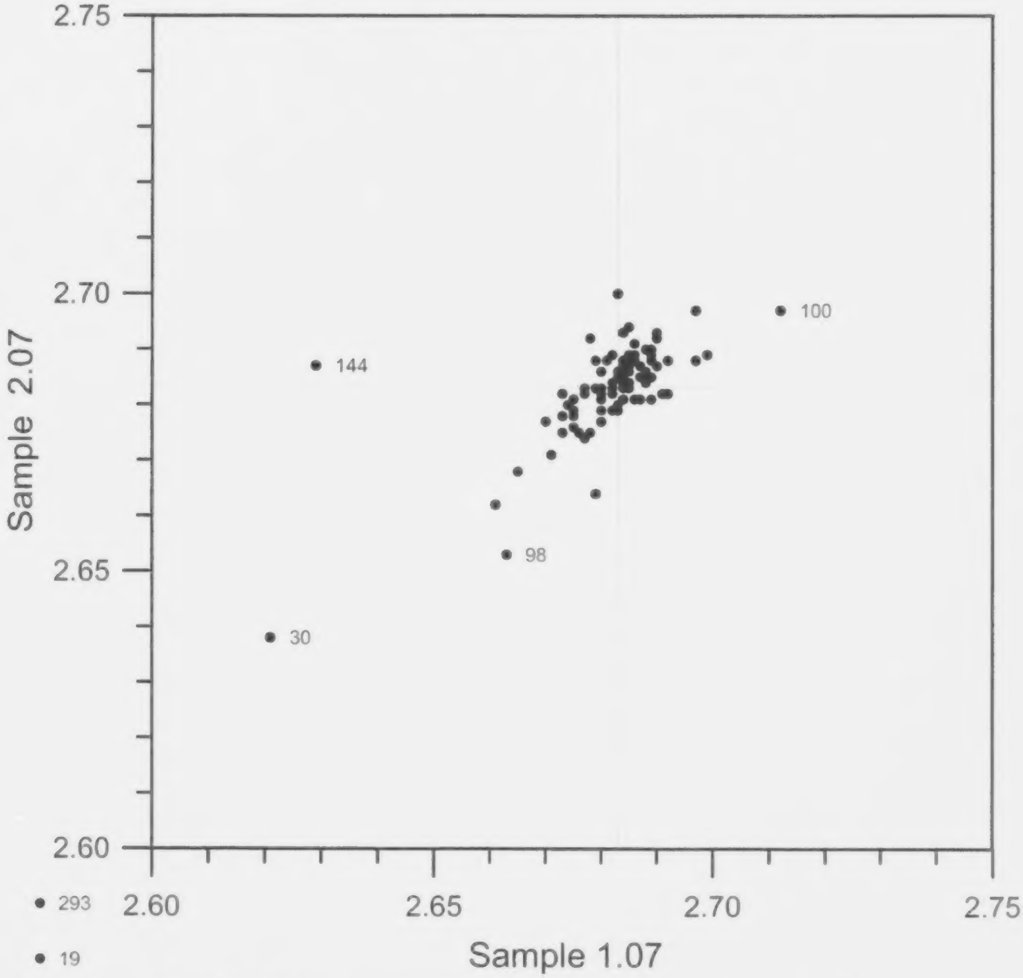


Test 8: Los Angeles Abrasion Loss, %

	Mat 1	Mat 2
Mean	23.456	23.500
Median	23.350	23.650
Std Dev	0.707	1.122
n = 9		

Labs Eliminated: 80

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

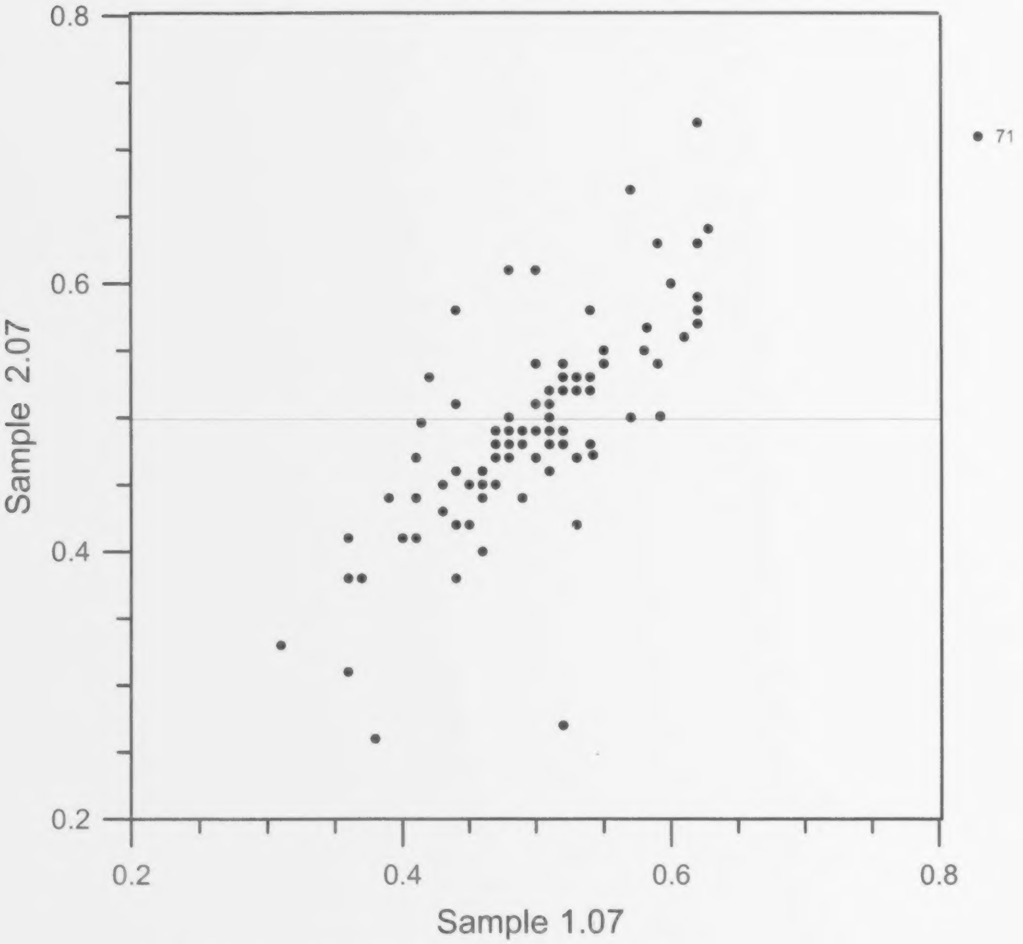


Test 9: Relative Density, (Coarse Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.683	2.684
Median	2.680	2.681
Std Dev	0.007	0.006
n = 90		

Labs Eliminated: 19; 30; 98; 100; 144; 293

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

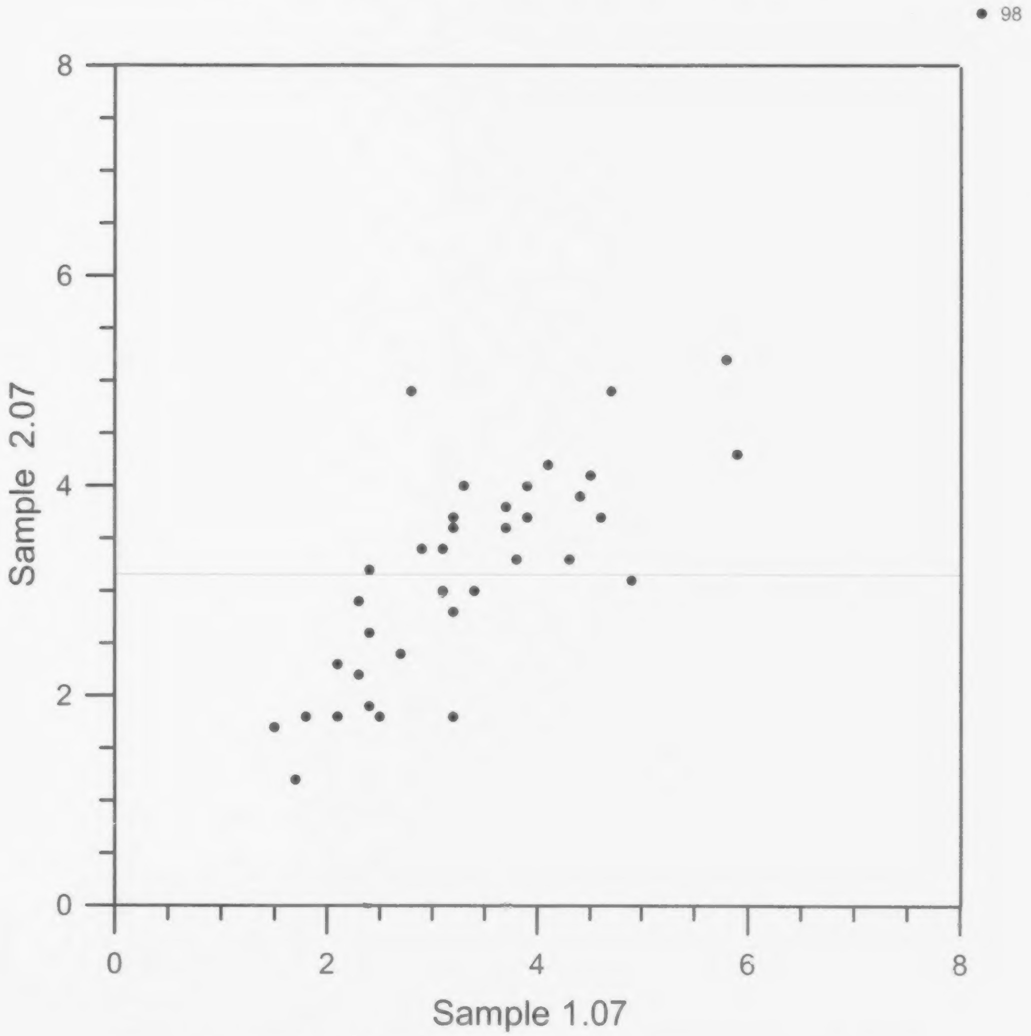


Test 10: Absorption (Coarse Aggregate)

	Mat 1	Mat 2
Mean	0.497	0.494
Median	0.469	0.490
Std Dev	0.066	0.079
n = 95		

Labs Eliminated: 71

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

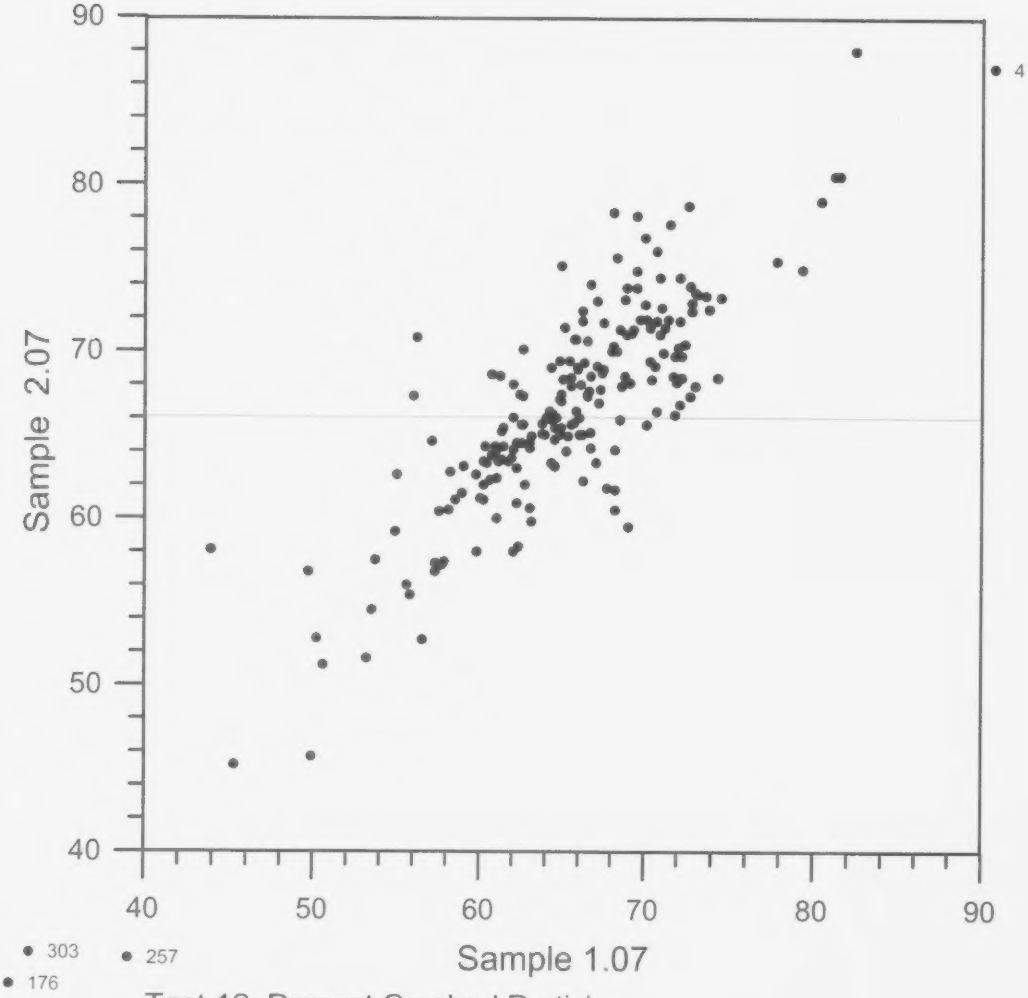


Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	3.328	3.181
Median	3.700	3.200
Std Dev	1.091	1.000
n = 36		

Lab Eliminated: 98

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

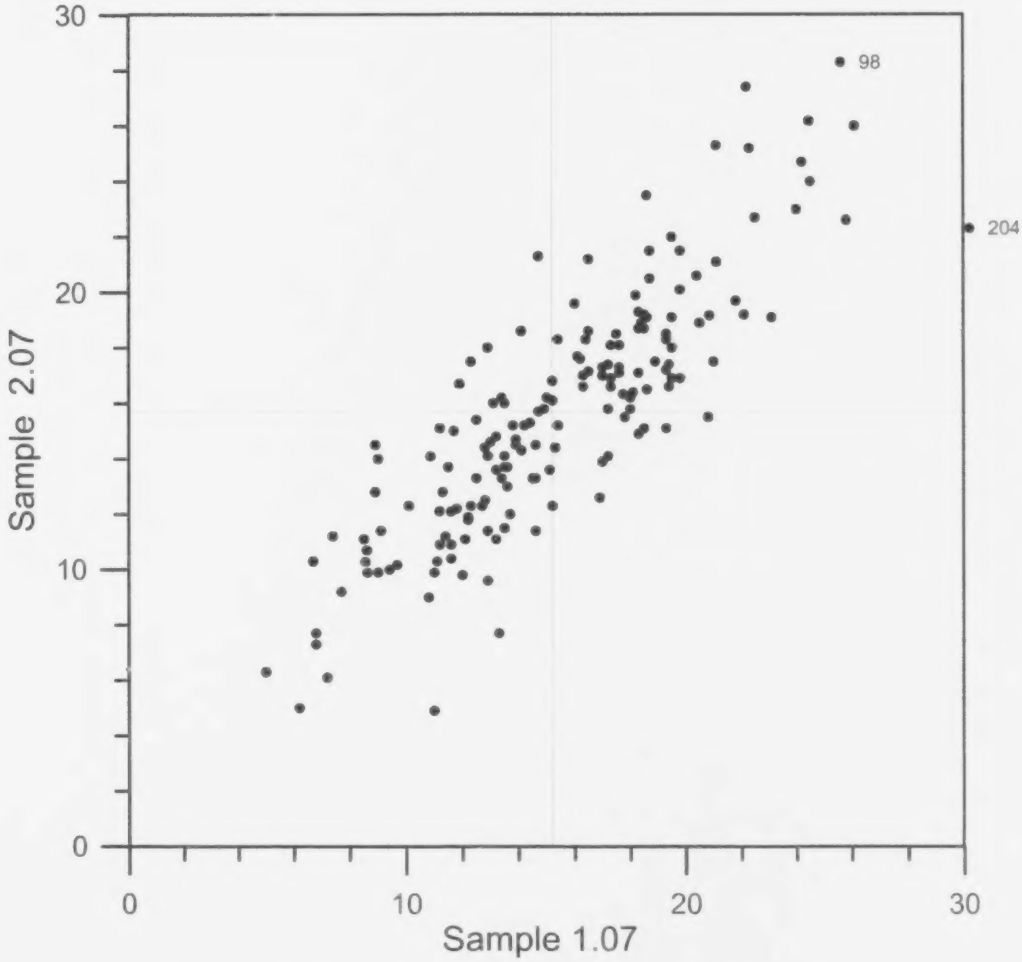


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	65.236	66.835
Median	63.150	66.600
Std Dev	6.396	6.251
n = 201		

Labs Eliminated: 4; 176; 257; 303

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

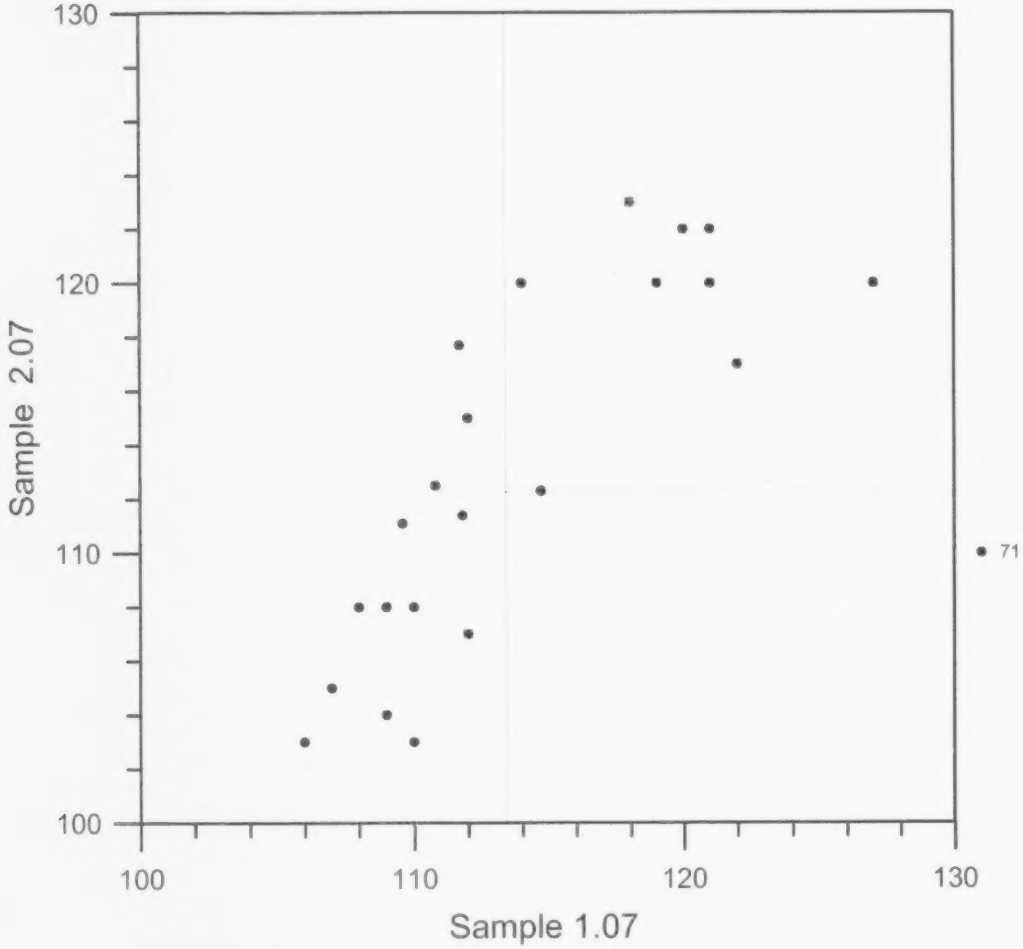


Test 13: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	15.332	15.557
Median	15.550	16.155
Std Dev	4.398	4.308
n = 164		

Labs Eliminated: 98; 204

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



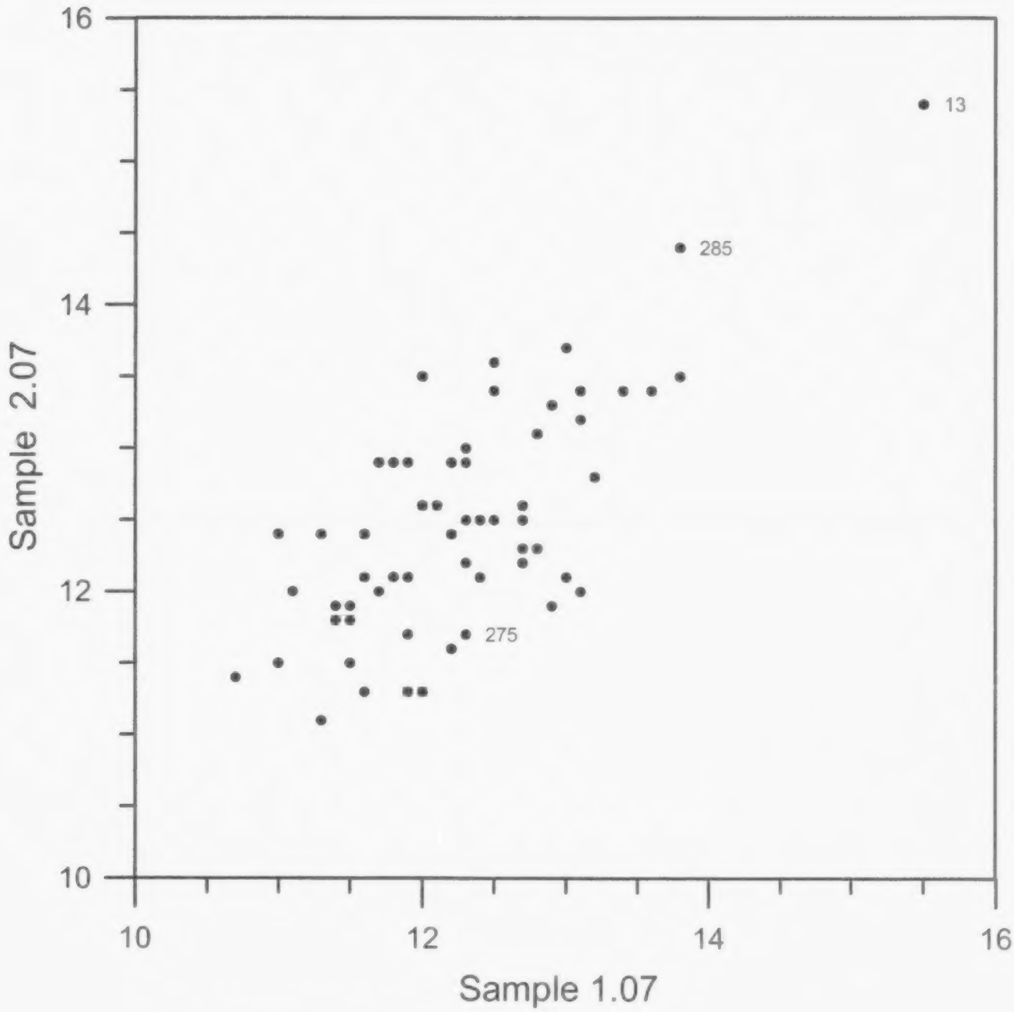
Test 14: Petrographic Number (Concrete)

	Mat 1	Mat 2
Mean	113.6	112.7
Median	116.5	113.0
Std Dev	5.7	6.7

n = 23

Lab Eliminated: 71

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

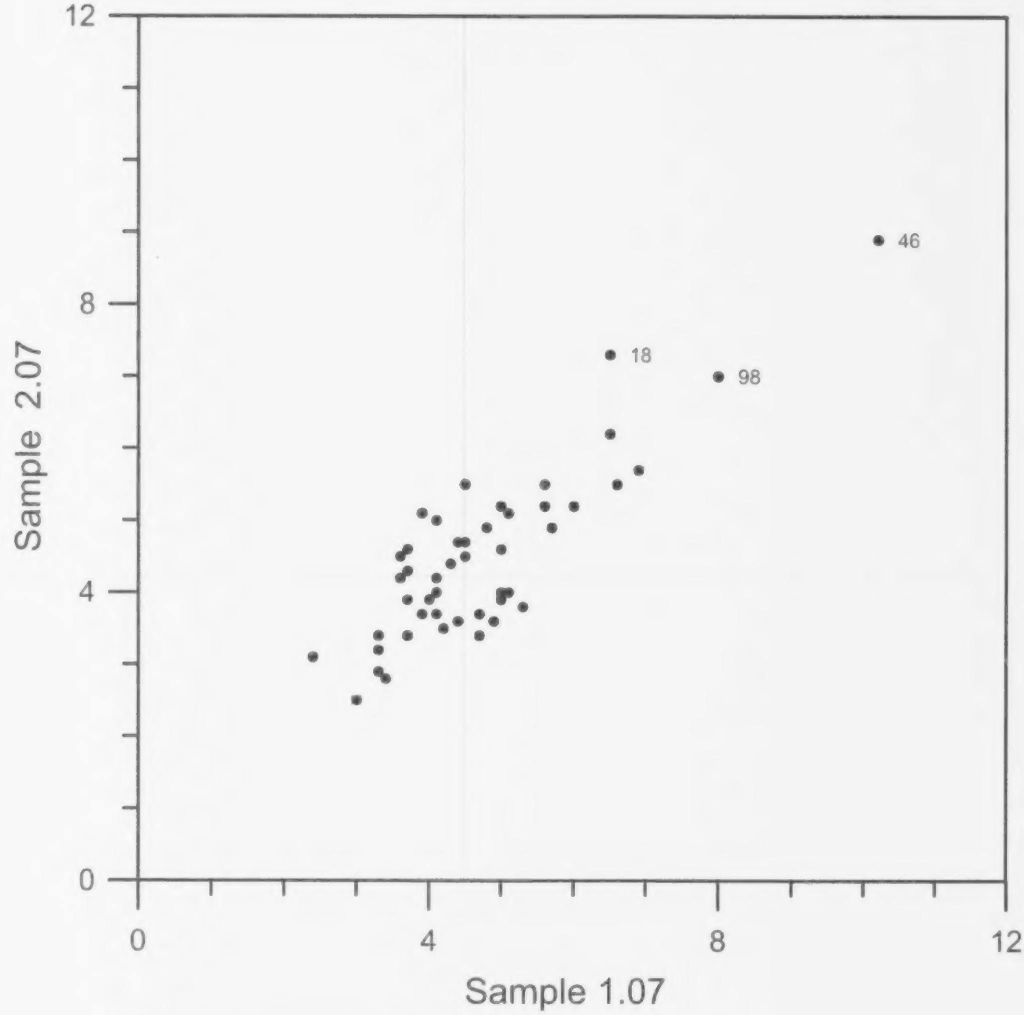


Test 16: Micro-Deval Abrasion Loss (CA), %

	Mat 1	Mat 2
Mean	12.228	12.422
Median	12.250	12.400
Std Dev	0.703	0.666
n = 60		

Labs eliminated: 13, 275, 285

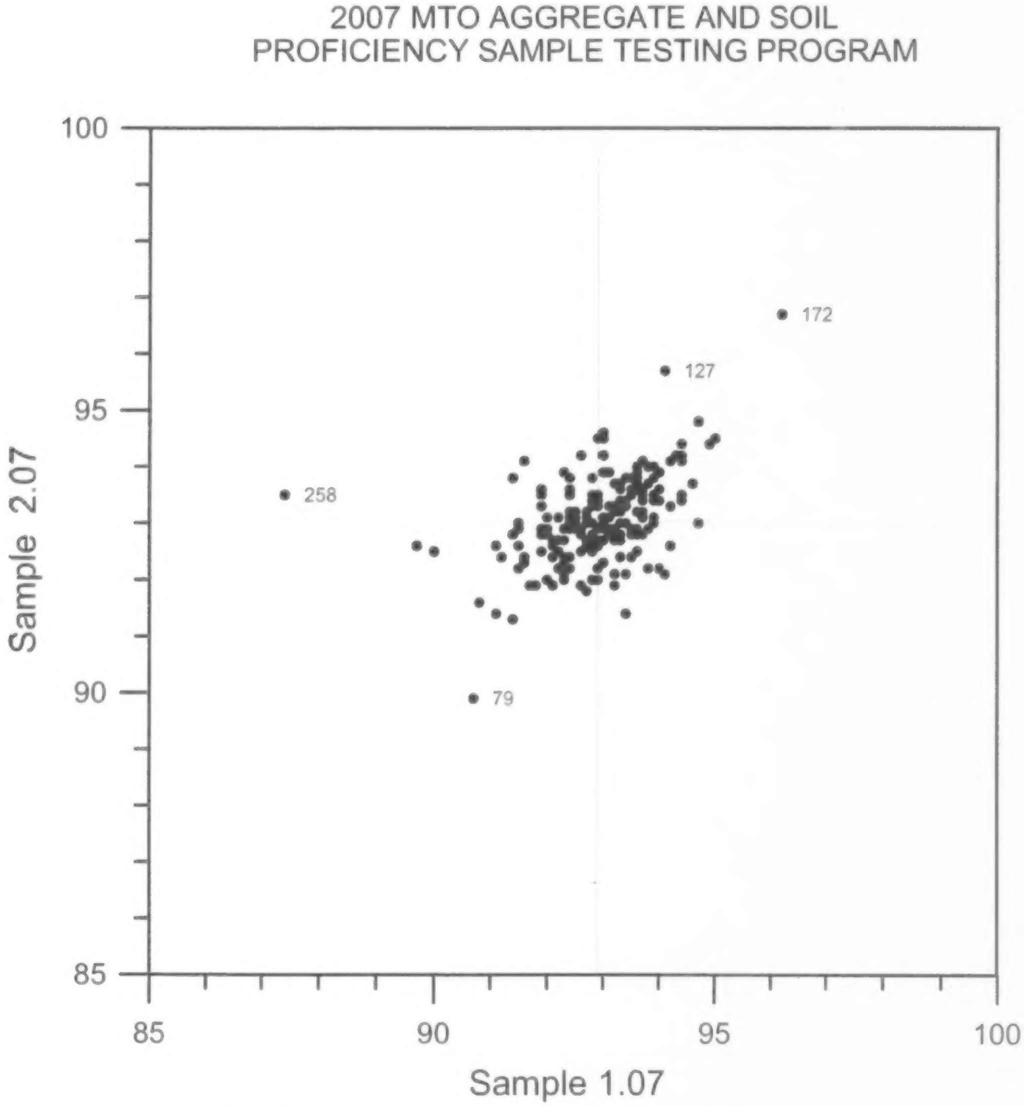
2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 17: Freeze-Thaw Loss, %

	Mat 1	Mat 2
Mean	4.528	4.276
Median	4.650	4.350
Std Dev	0.996	0.849
n = 46		

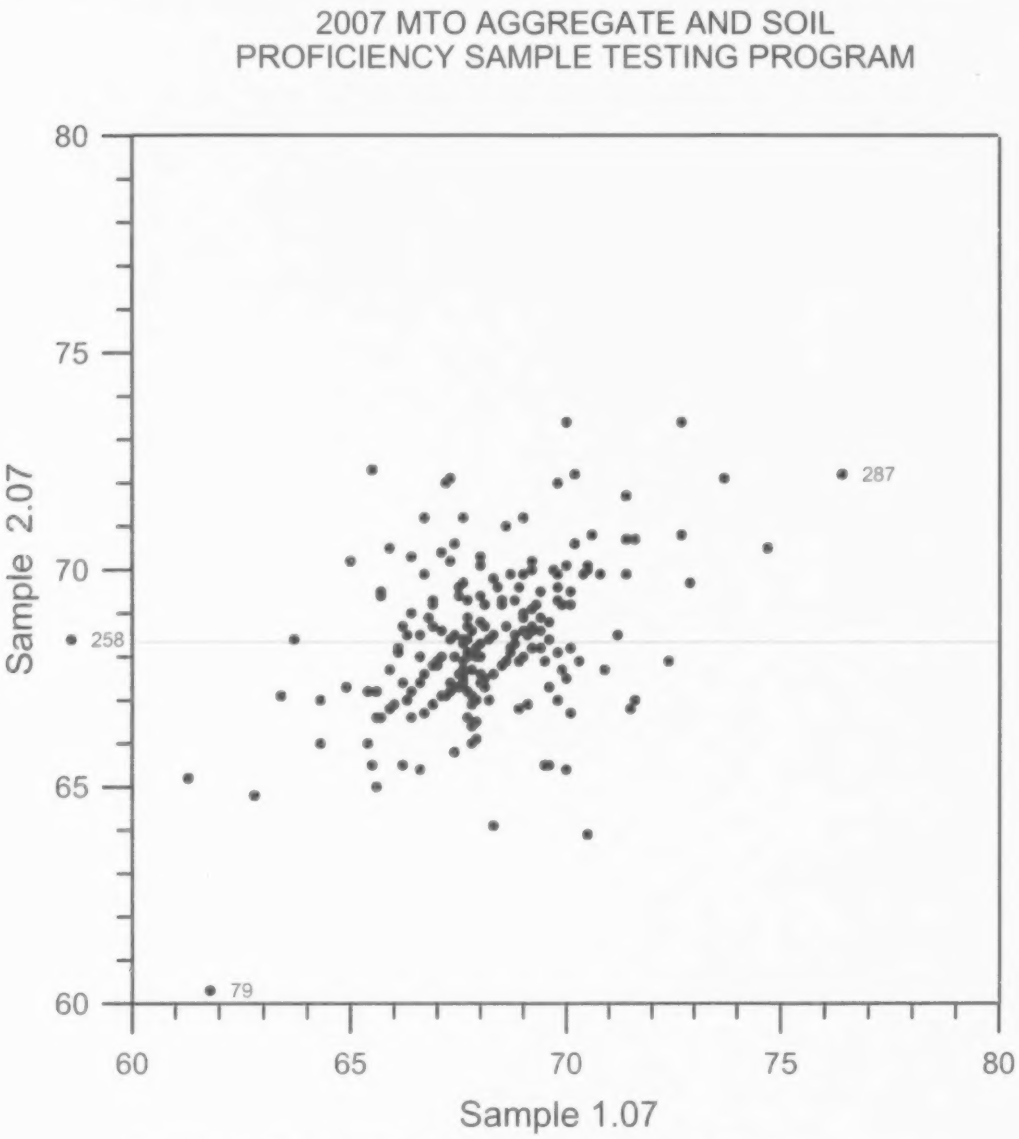
Lab eliminated: 18; 46; 98



Test 20: Percent Passing the 2.36 mm Sieve

	Mat 1	Mat 2
Mean	92.945	93.044
Median	92.350	93.050
Std Dev	0.918	0.661
n = 201		

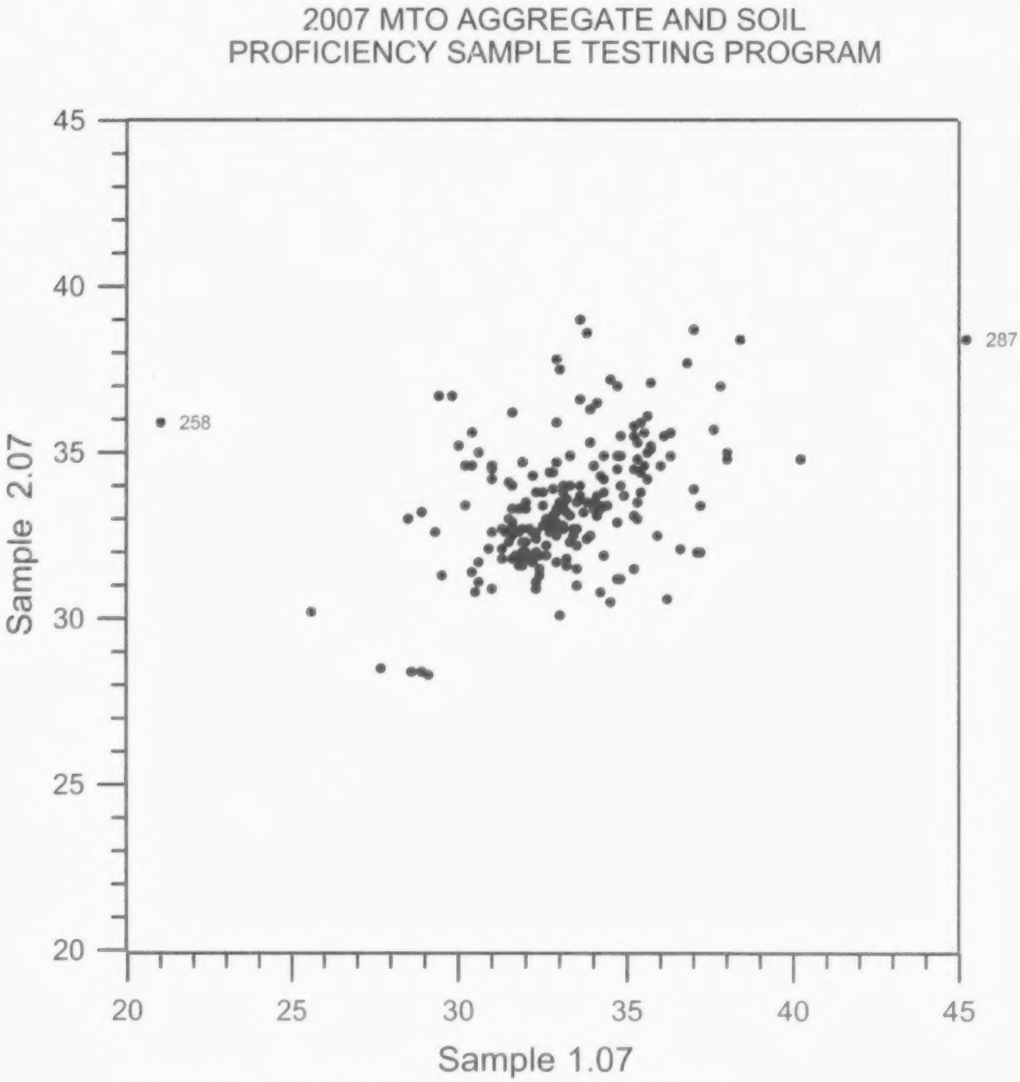
Labs Eliminated: 79; 127; 172; 258



Test 21: Percent Passing the 1.18 mm Sieve

	Mat 1	Mat 2
Mean	68.126	68.421
Median	68.000	68.650
Std Dev	1.945	1.665
n = 202		

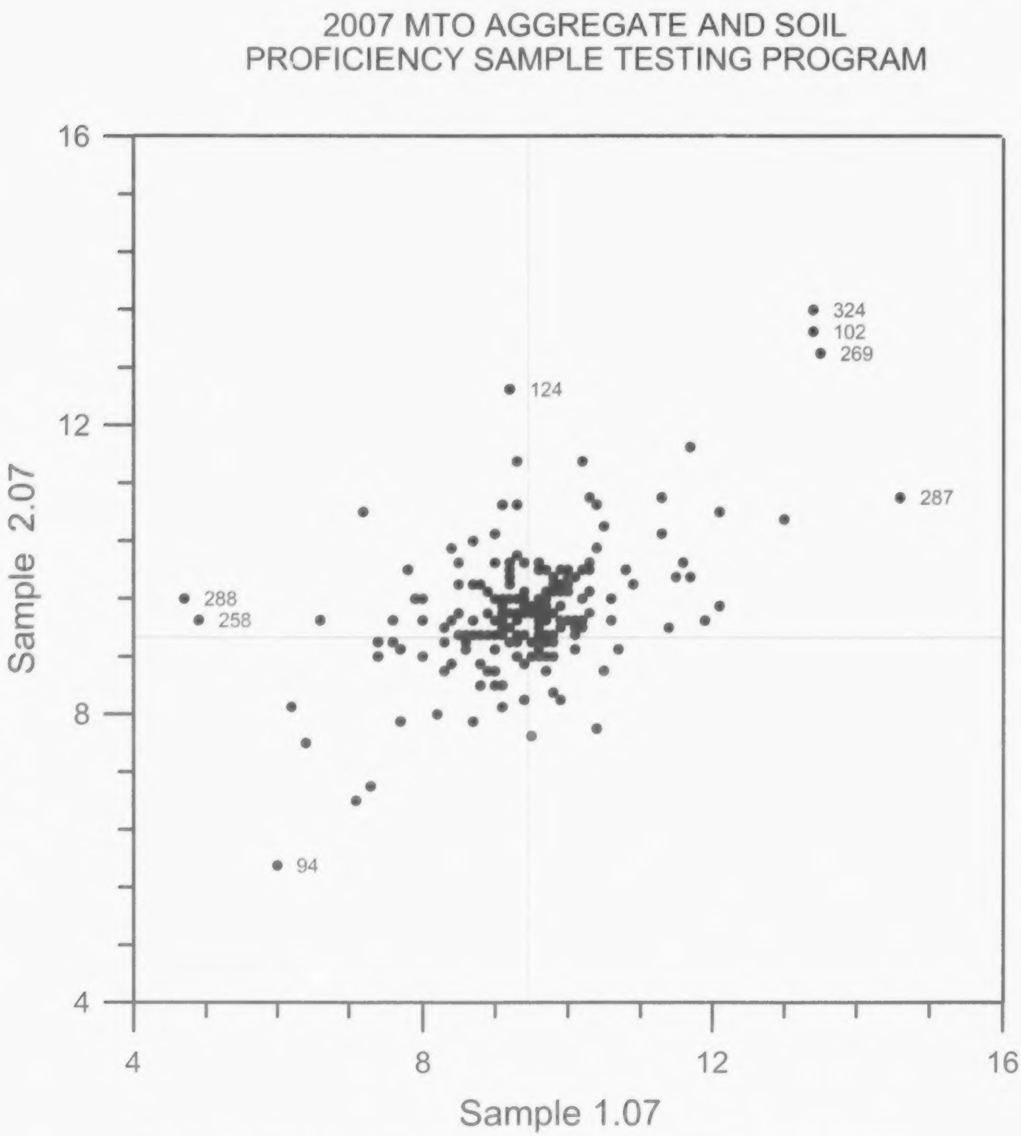
Labs Eliminated: 79; 258; 287



Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	33.212	33.488
Median	32.900	33.650
Std Dev	2.112	1.900
n = 203		

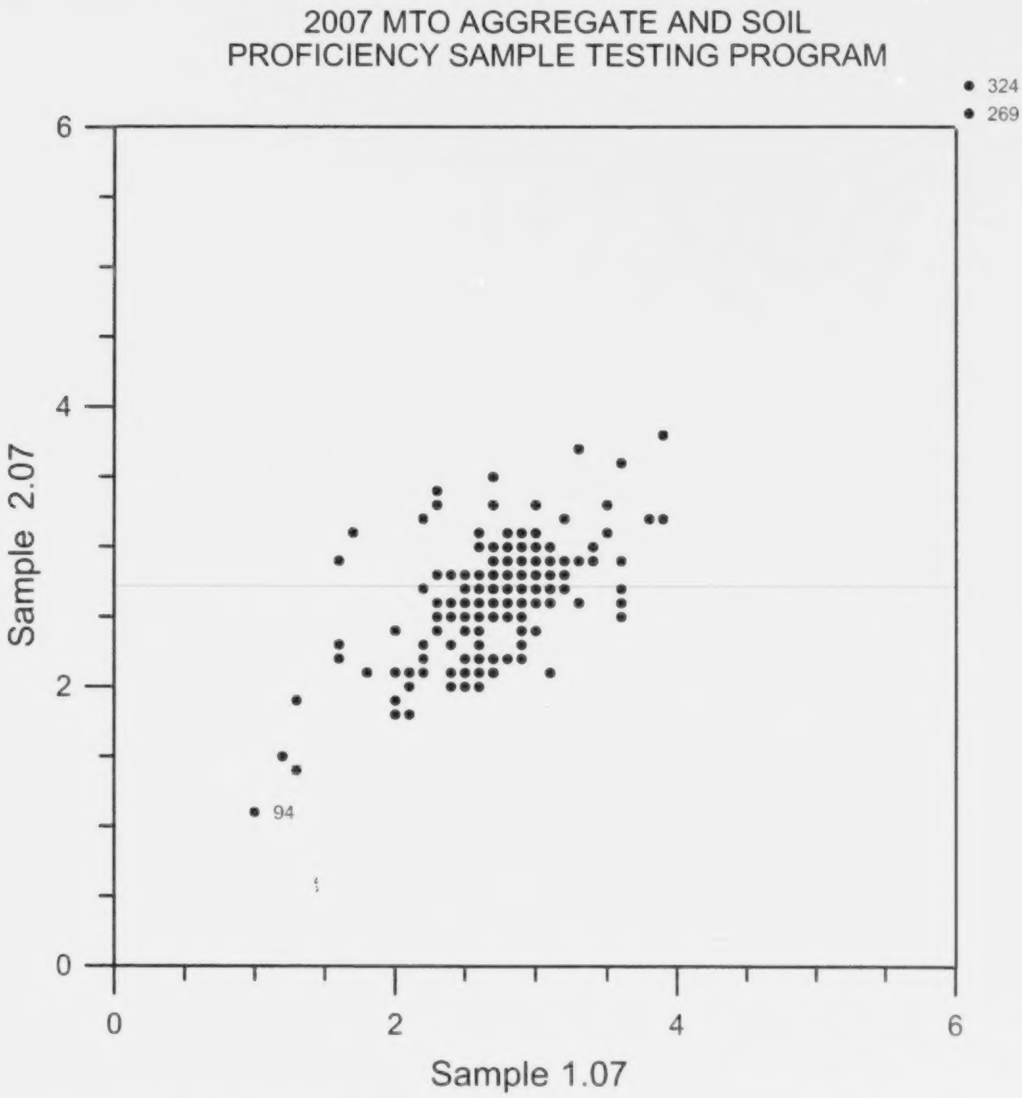
Lab Eliminated: 258; 287



Test 23: Percent Passing the 300 um Sieve

	Mat 1	Mat 2
Mean	9.467	9.403
Median	9.600	9.250
Std Dev	1.123	0.727
n = 197		

Lab Eliminated: 94; 102; 124; 258; 269; 287; 288; 324

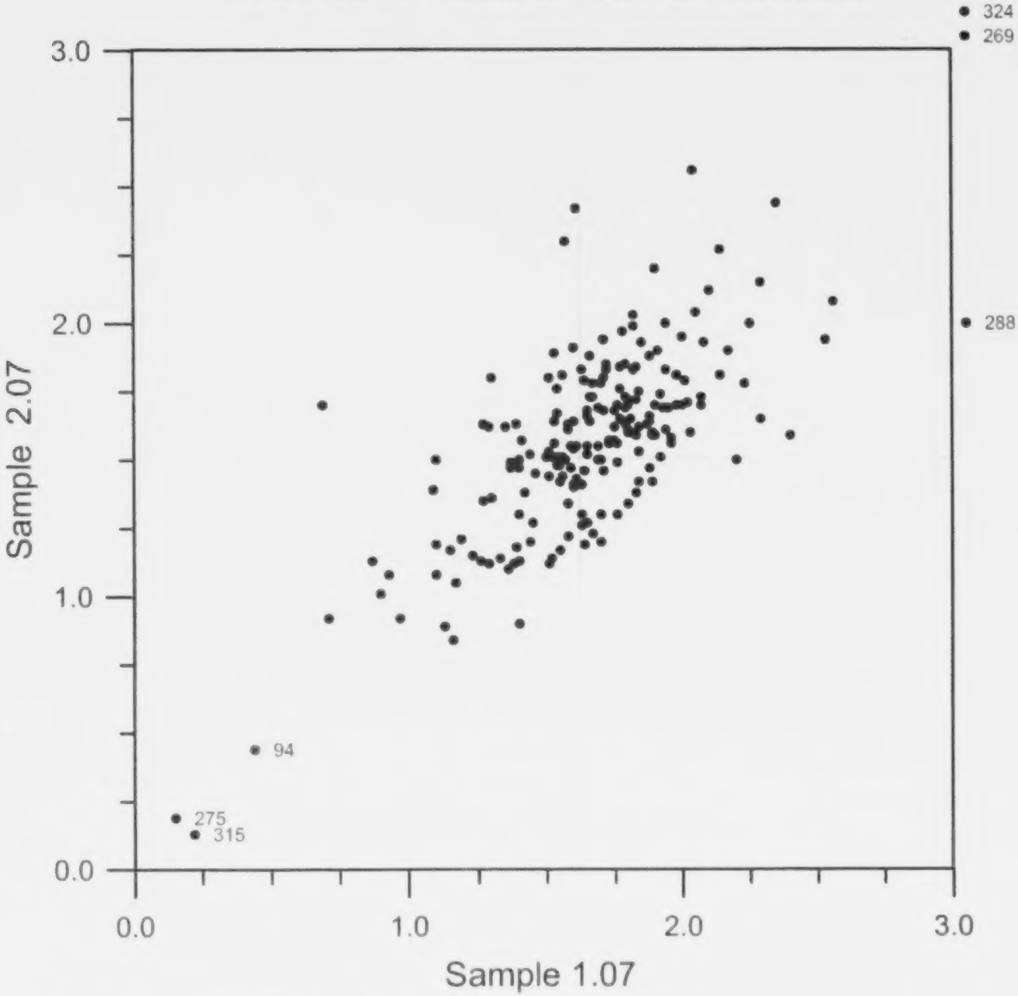


Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	2.731	2.651
Median	2.550	2.600
Std Dev	0.439	0.370
n = 202		

Lab Eliminated: 94; 269; 324

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



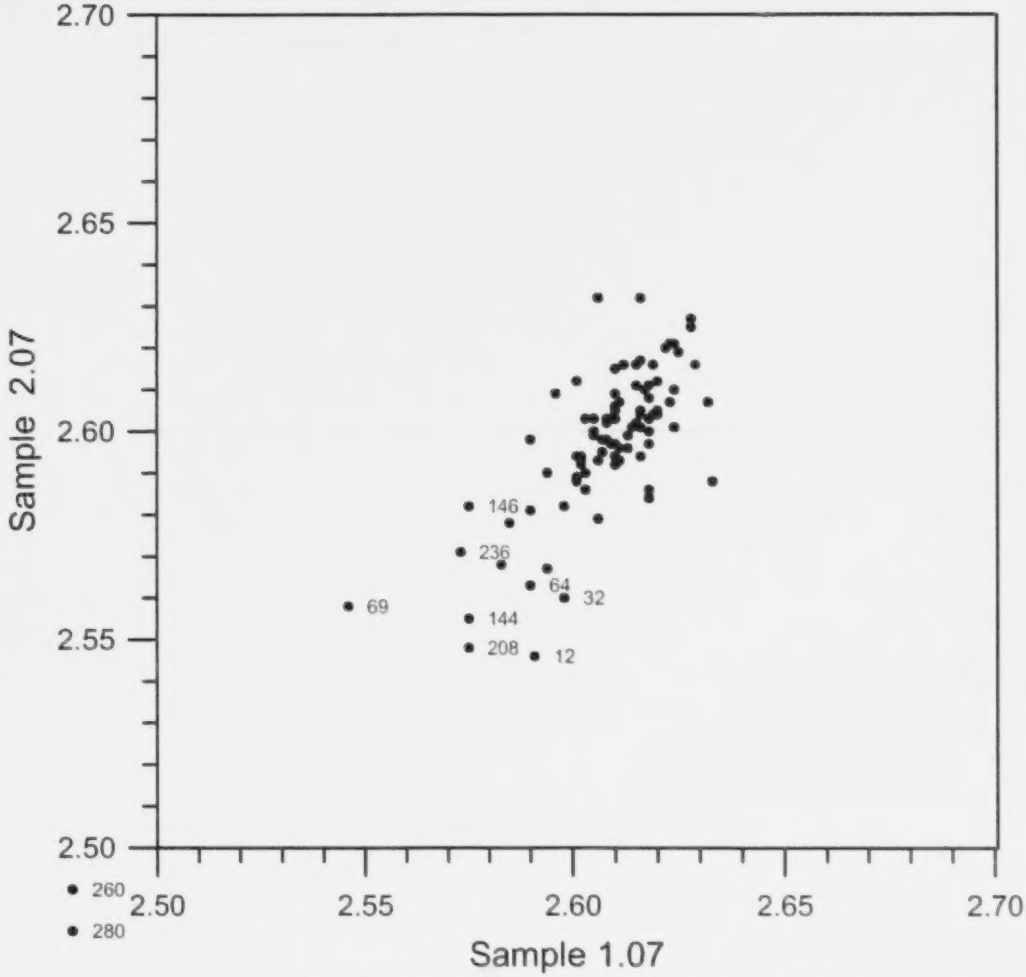
Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	1.671	1.576
Median	1.625	1.700
Std Dev	0.307	0.305

n = 199

Labs Eliminated: 94; 269; 275; 286; 315; 324

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

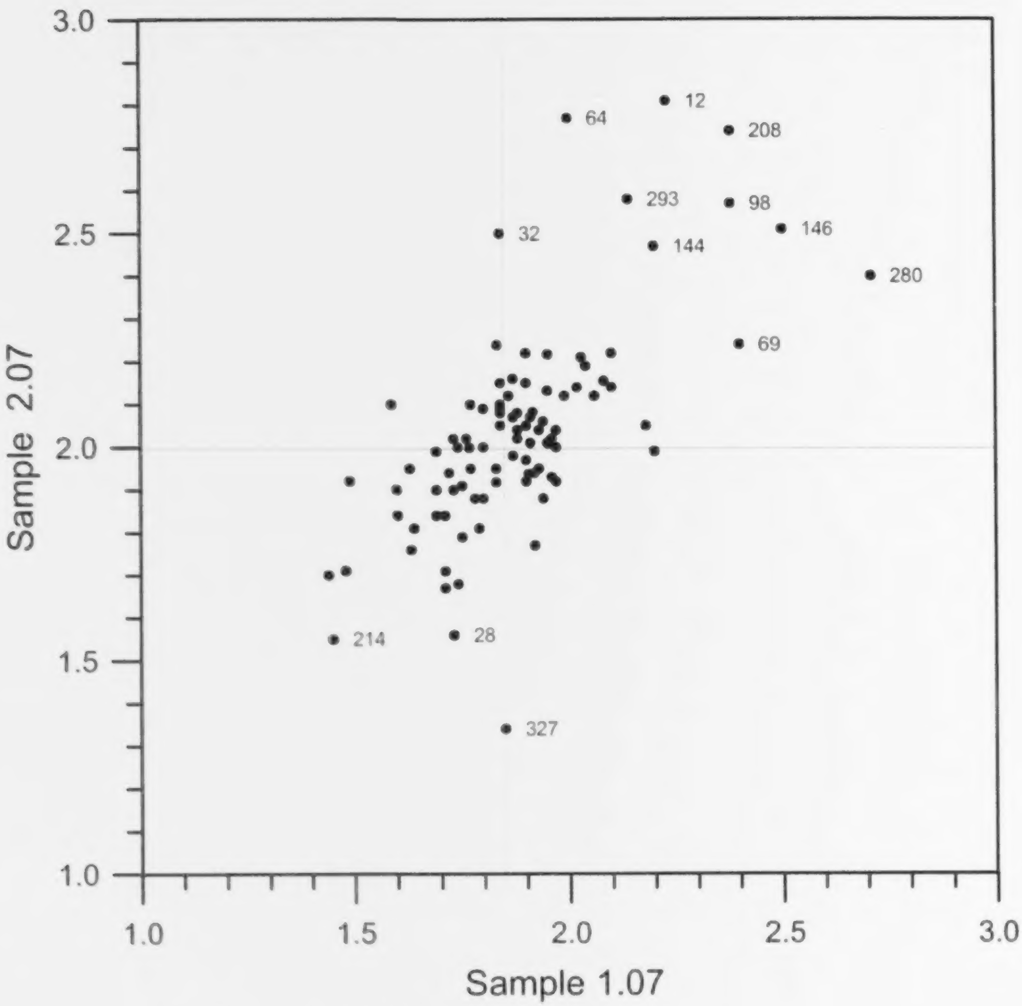


Test 27: Relative Density, (Fine Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.611	2.601
Median	2.608	2.600
Std Dev	0.011	0.013
n = 83		

Labs Eliminated: 12; 32; 64; 69; 144; 146; 208; 236; 260; 280

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

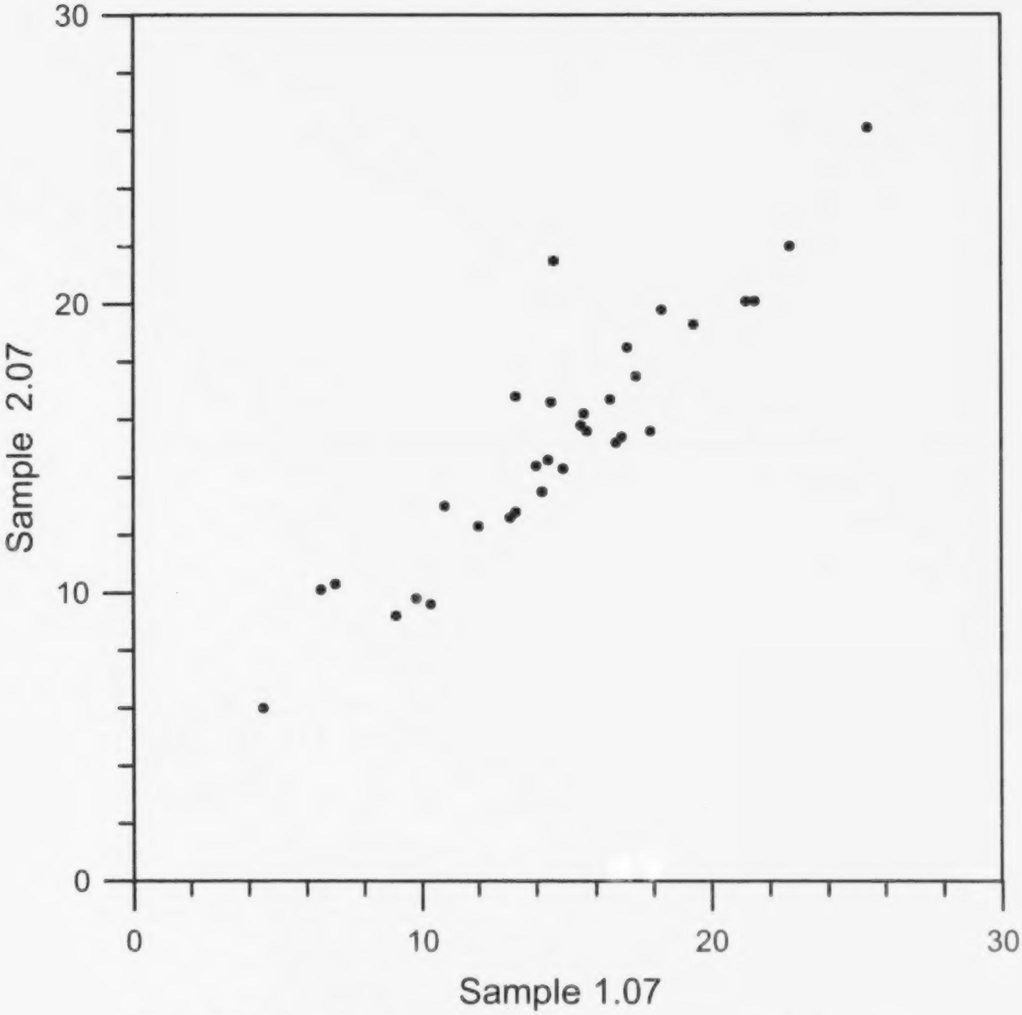


Test 28: Absorption (Fine Aggregate)

	Mat 1	Mat 2
Mean	1.849	1.993
Median	1.820	1.955
Std Dev	0.164	0.139
n = 80		

Labs Eliminated: 12; 28; 32; 64; 69; 98; 144; 146; 208; 214; 280; 293; 327

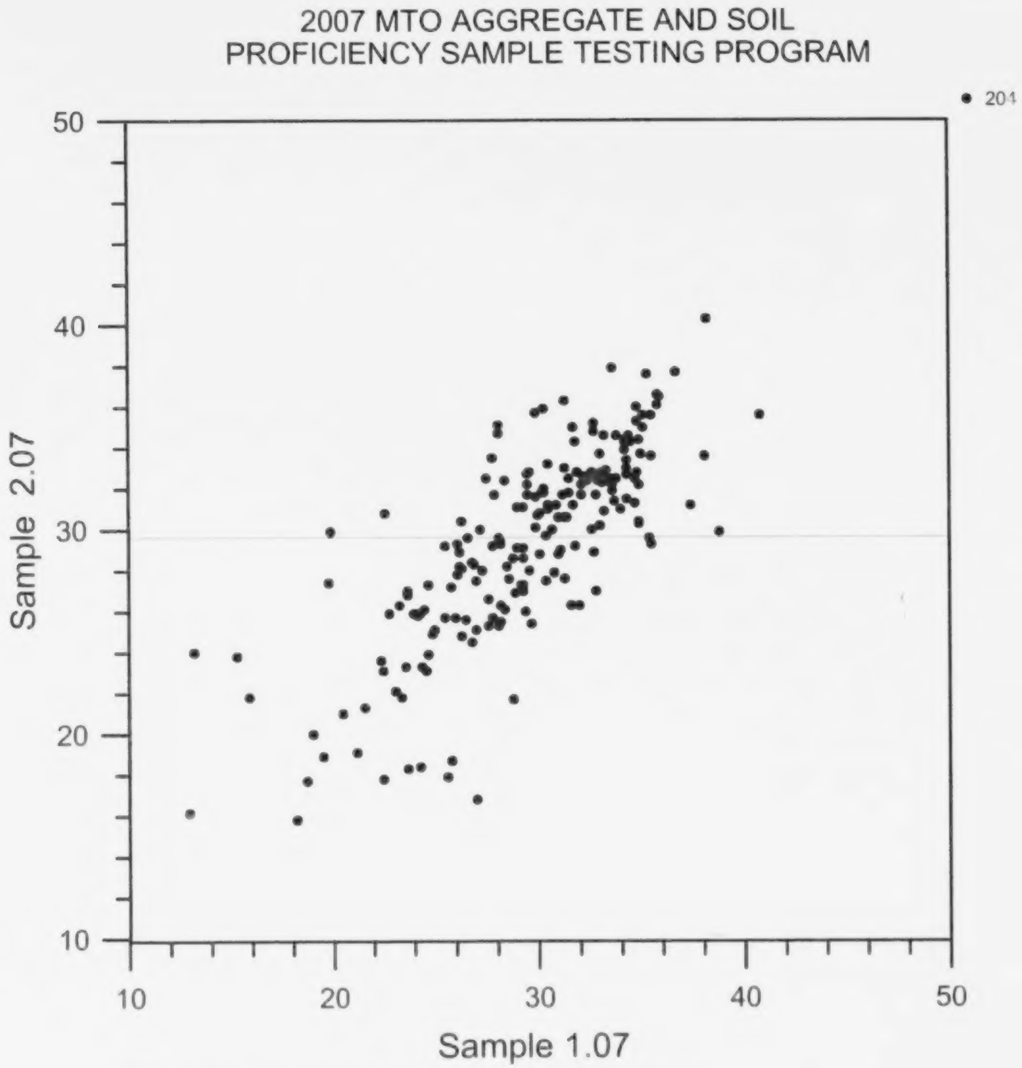
2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	14.816	15.353
Median	14.950	16.050
Std Dev	4.665	4.312
n = 32		

Lab Eliminated: None

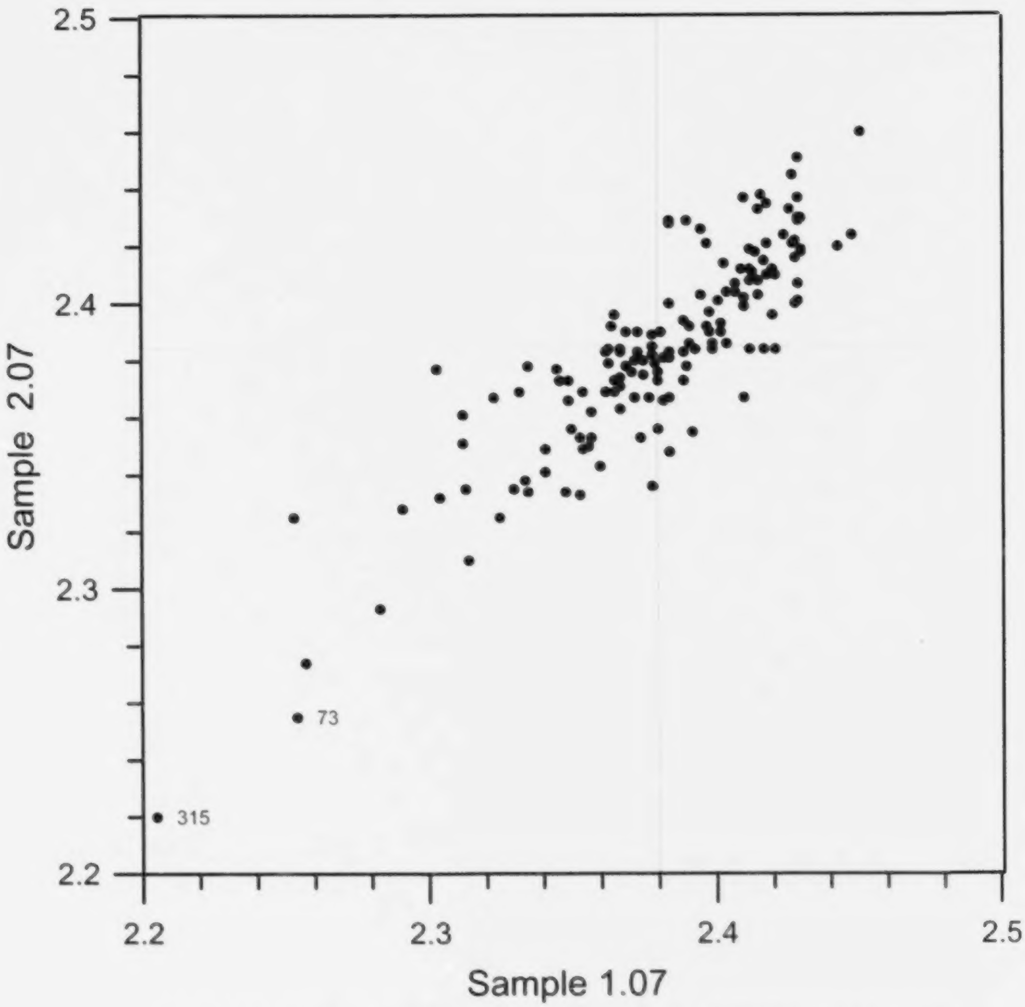


Test 30: Percent Asphalt Coated Particles

	Mat 1	Mat 2
Mean	29.477	29.431
Median	26.875	28.050
Std Dev	4.830	4.703
n = 203		

Lab Eliminated: 204

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

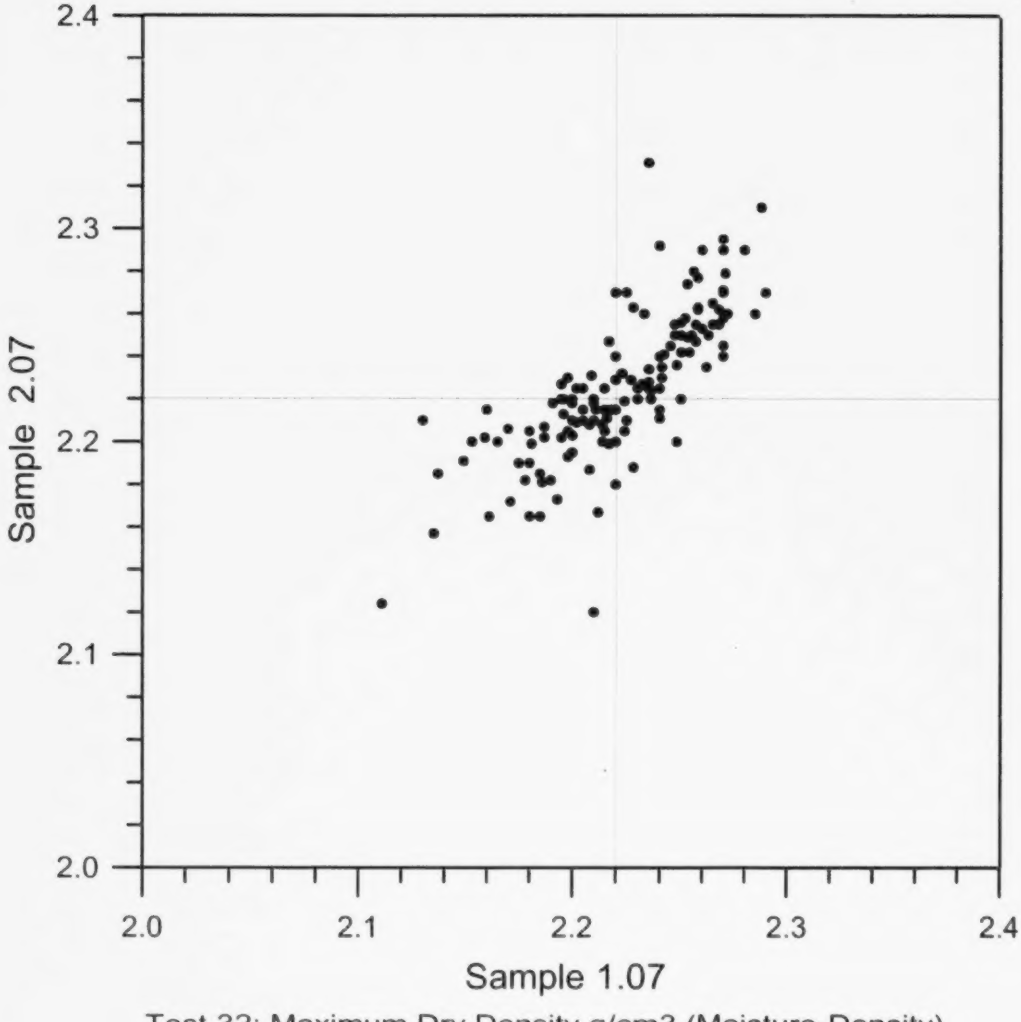


Test 31: Maximum Wet Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.382	2.385
Median	2.352	2.367
Std Dev	0.039	0.032
n = 145		

Labs Eliminated: 73; 315

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

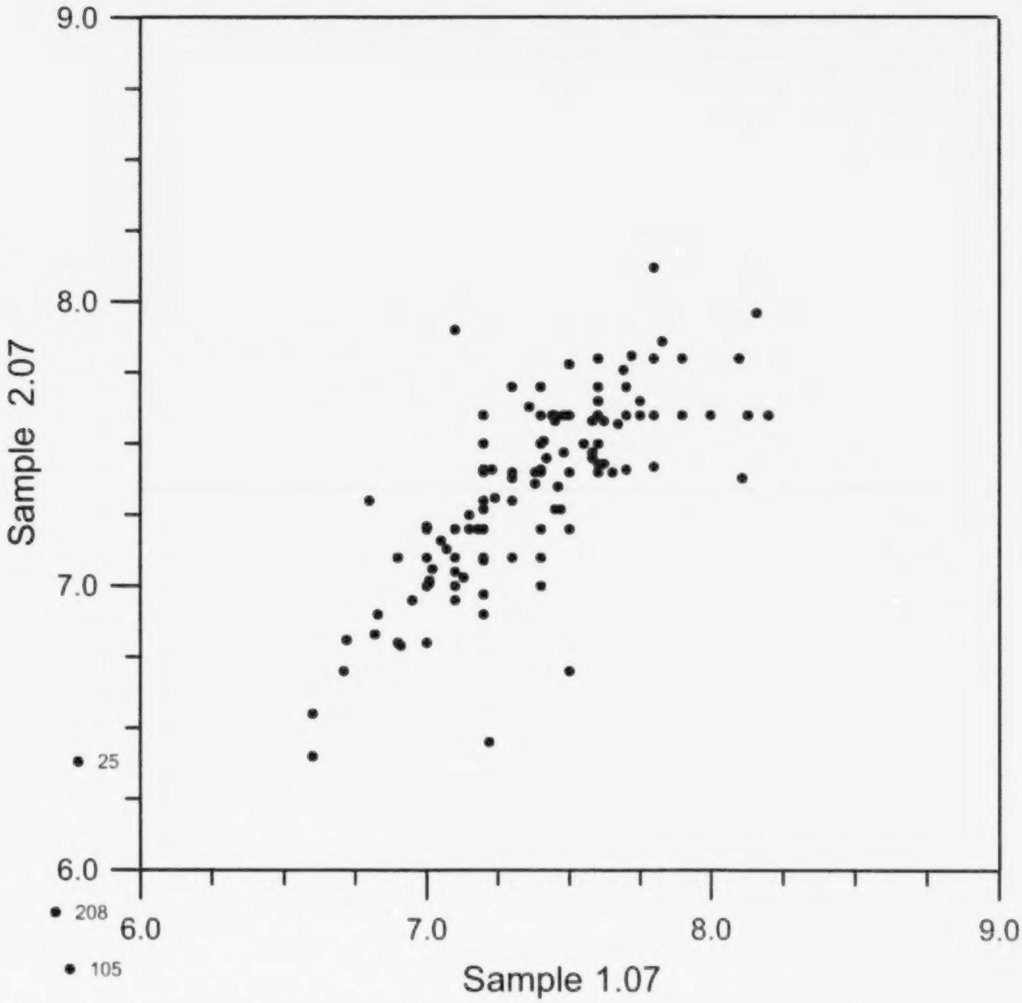


Test 32: Maximum Dry Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.223	2.226
Median	2.201	2.226
Std Dev	0.035	0.034
n = 147		

Labs Eliminated: None

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

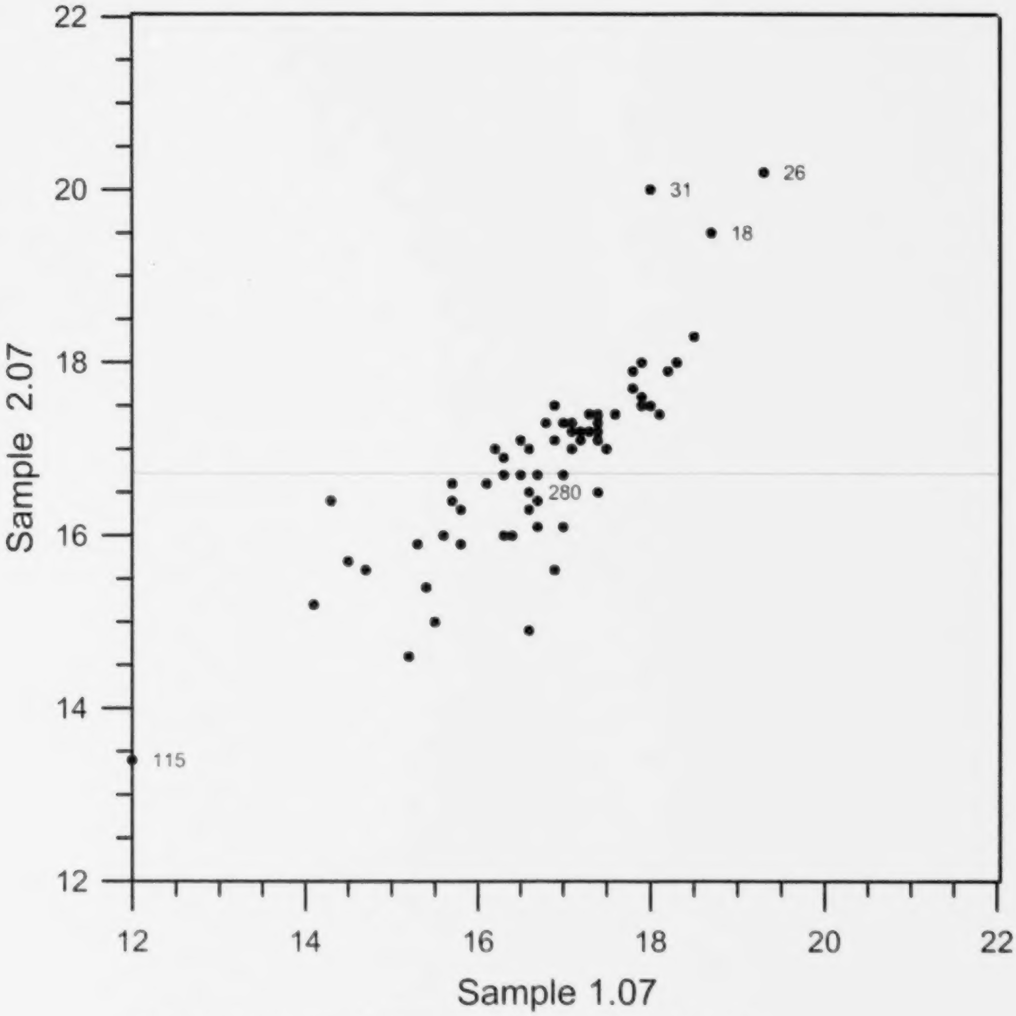


Test 33: Optimum Moisture, % (Moisture - Density)

	Mat 1	Mat 2
Mean	7.369	7.342
Median	7.400	7.260
Std Dev	0.320	0.319
n = 144		

Labs Eliminated: 25; 105; 208

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

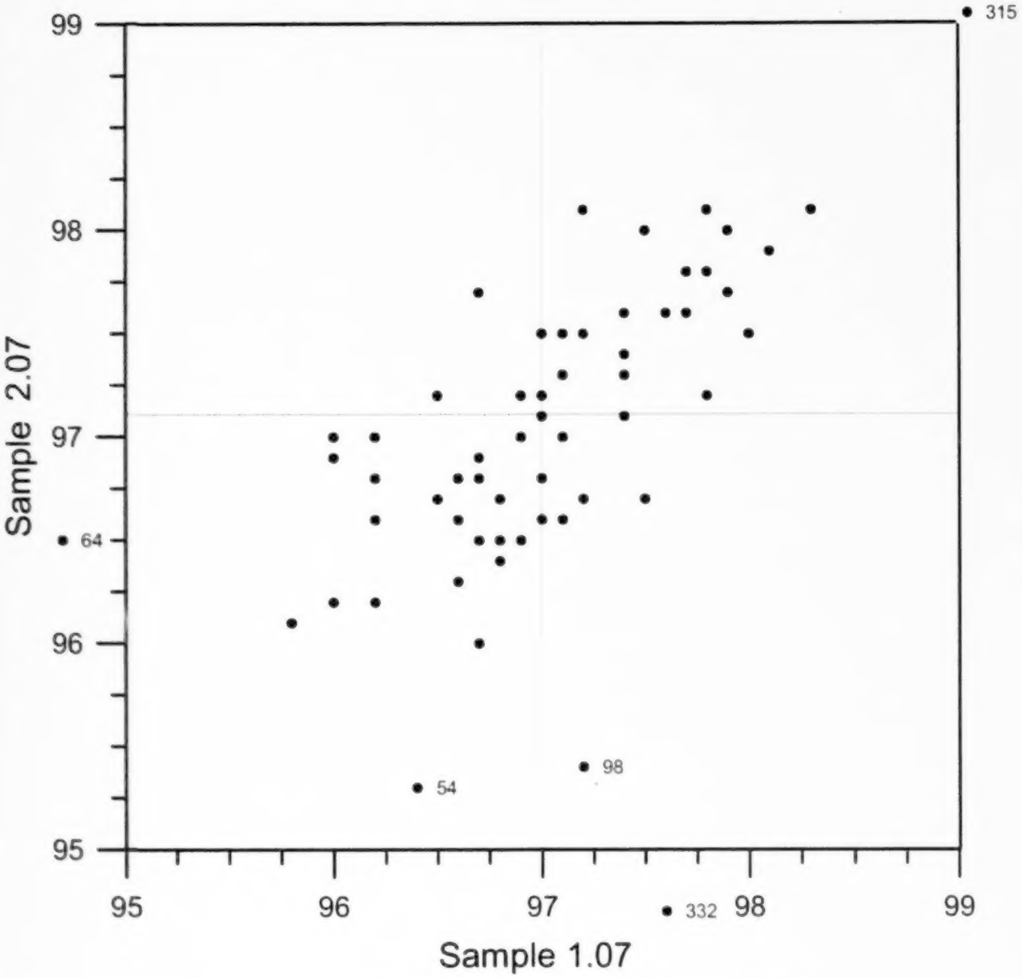


Test 34: Micro-Deval Abrasion Loss (FA), %

	Mat 1	Mat 2
Mean	16.810	16.743
Median	16.300	16.450
Std Dev	1.088	0.837
n = 58		

Lab eliminated: 18; 26; 31; 115; 280

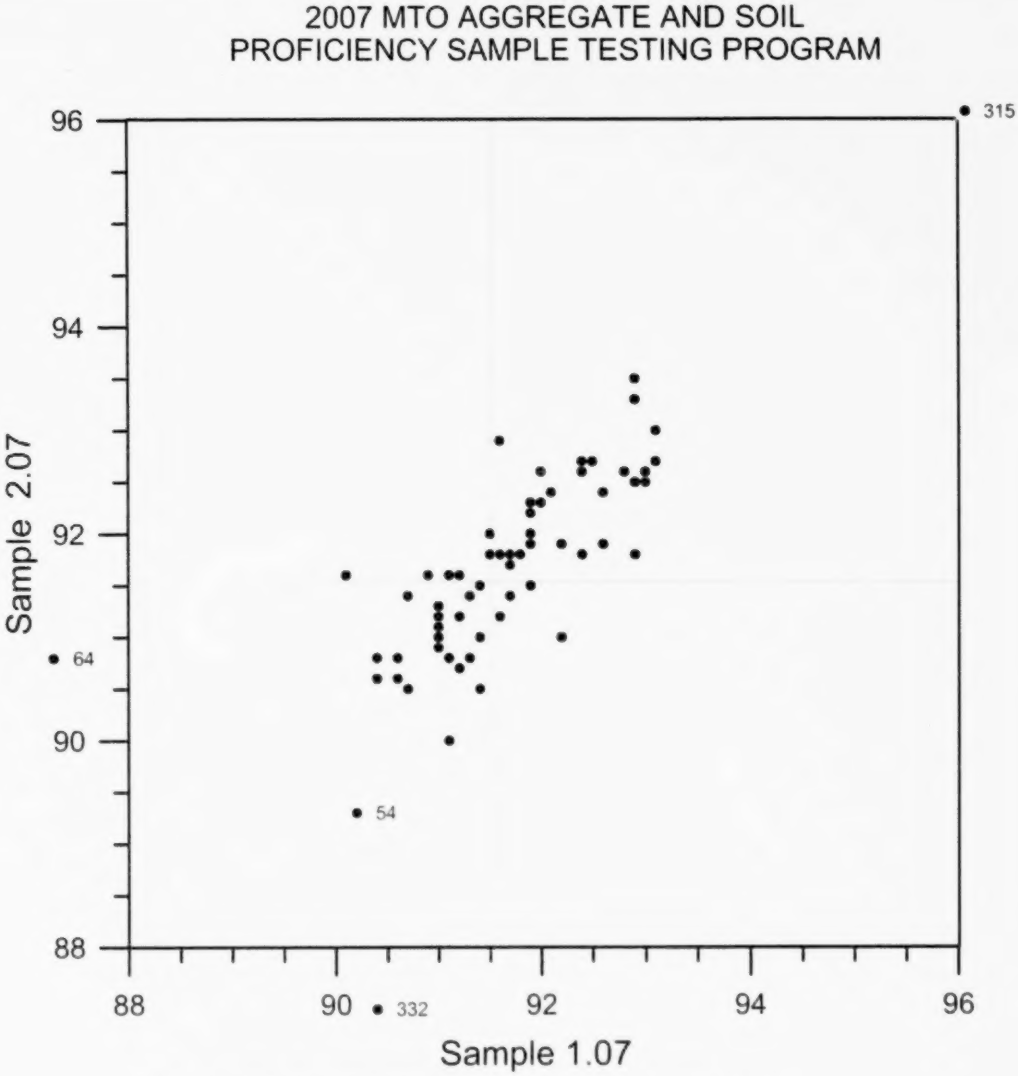
2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 41: Percent Passing the 425 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	97.014	97.076
Median	97.050	97.050
Std Dev	0.580	0.541
n = 61		

Labs eliminated: 54: 64; 98; 315; 332

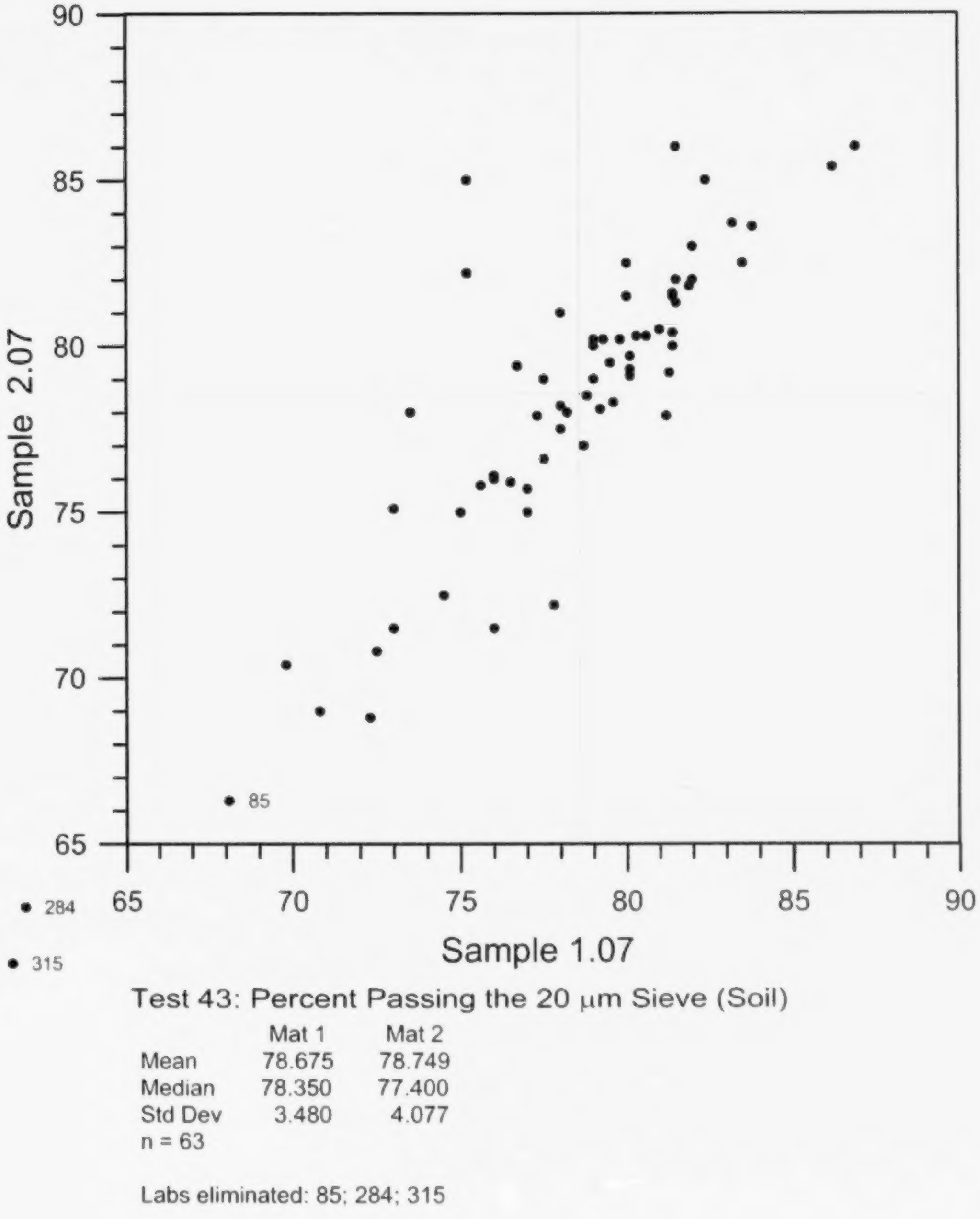


Test 42: Percent Passing the 75 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	91.628	91.670
Median	91.600	91.750
Std Dev	0.811	0.779
n = 62		

Labs eliminated: 54; 64; 315; 332

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

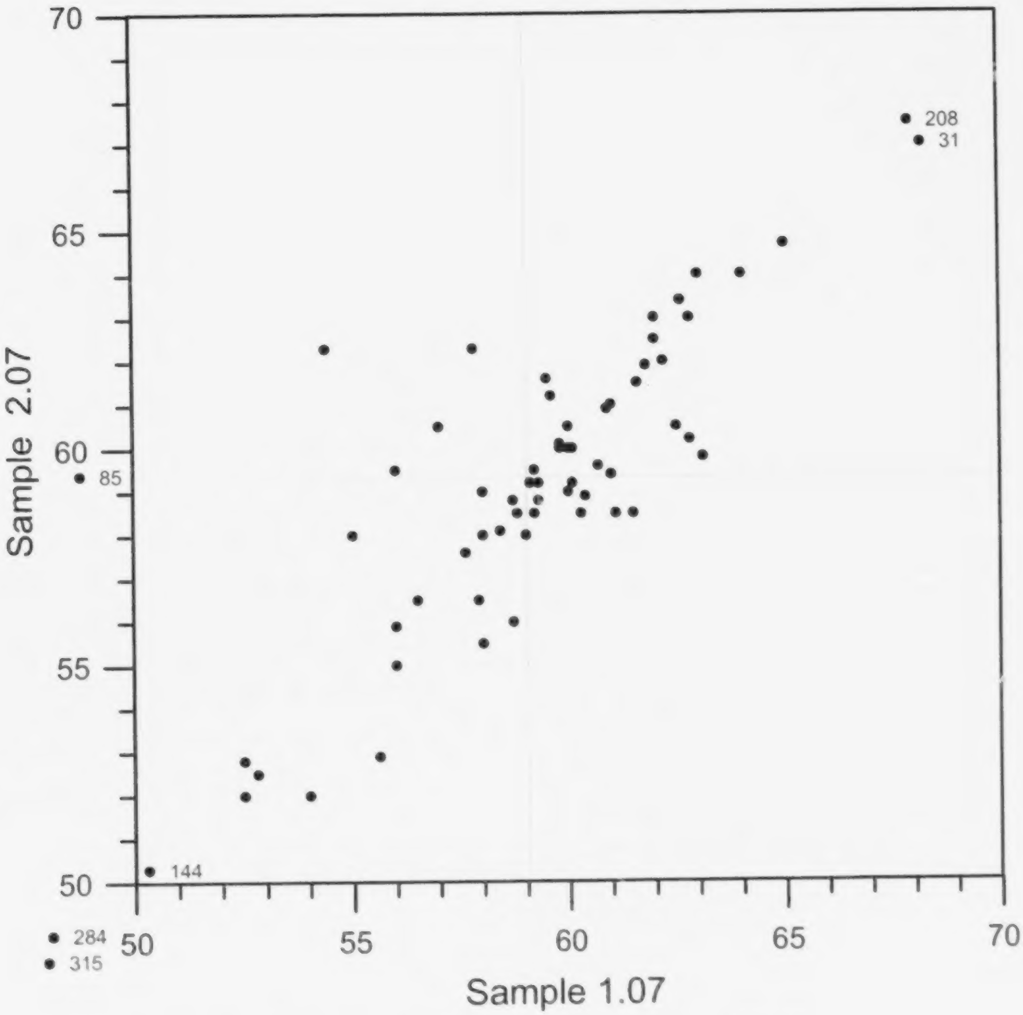


Test 43: Percent Passing the 20 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	78.675	78.749
Median	78.350	77.400
Std Dev	3.480	4.077
n = 63		

Labs eliminated: 85; 284; 315

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

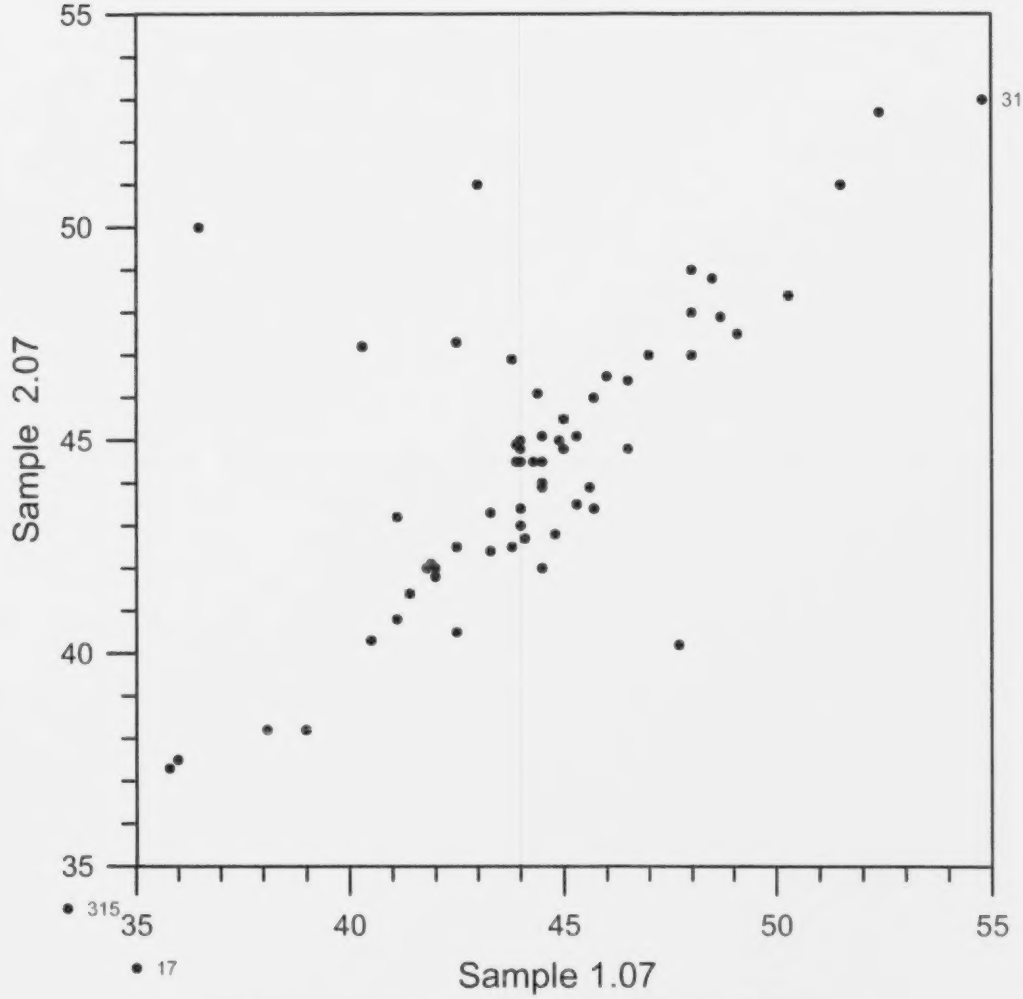


Test 44: Percent Passing the 5 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	59.242	59.440
Median	58.750	58.350
Std Dev	2.816	3.214
n = 60		

Labs eliminated: 31; 85; 144; 208; 284; 315

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

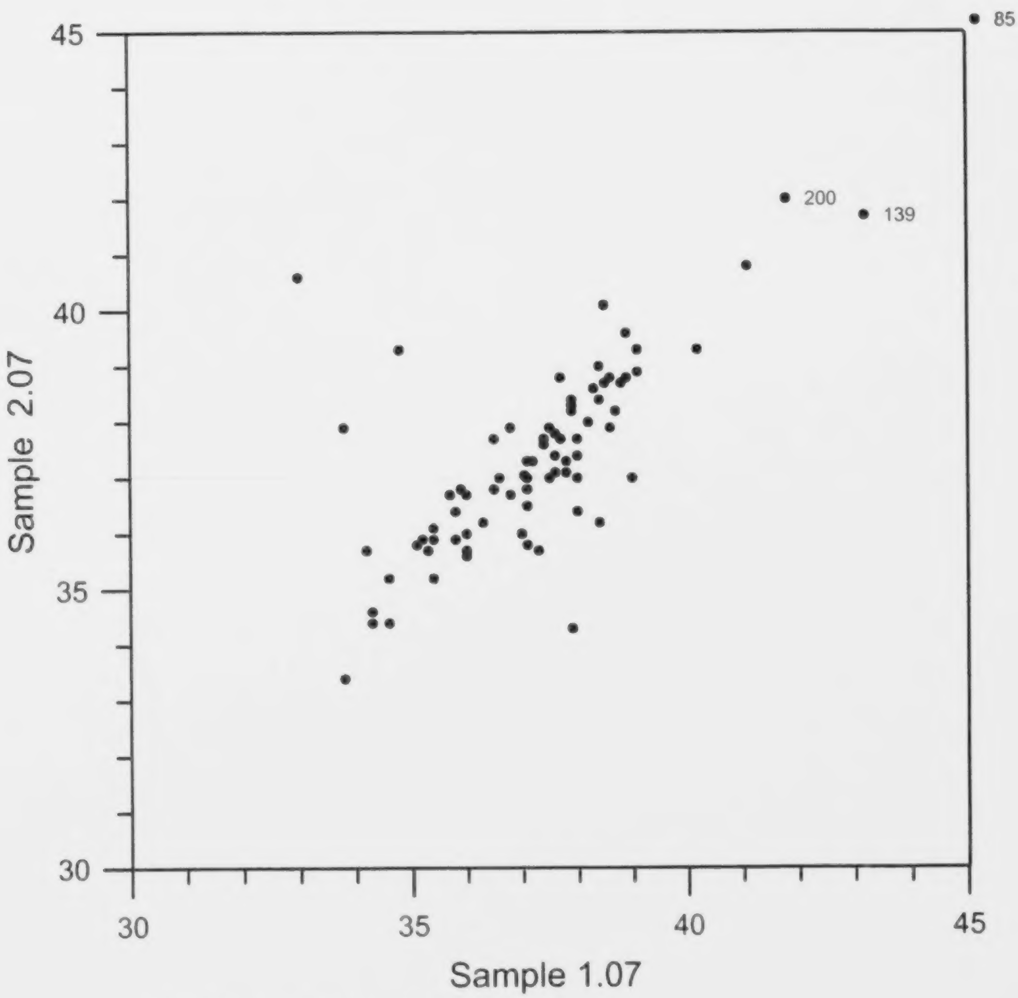


Test 45: Percent Passing the 2 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	44.034	44.570
Median	44.100	45.000
Std Dev	3.443	3.357
n = 63		

LabsEliminated: 17; 31; 315

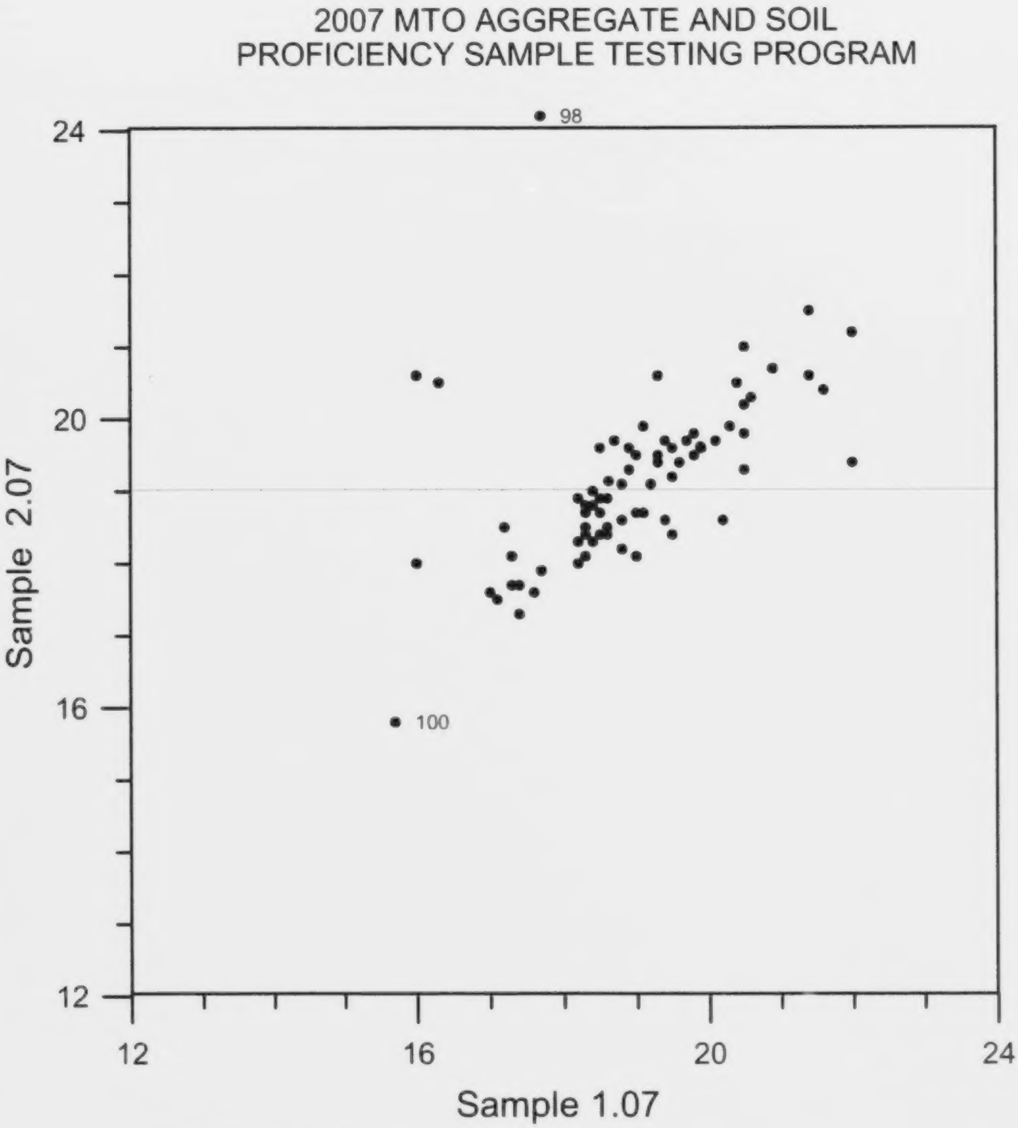
2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	37.032	37.190
Median	37.050	37.100
Std Dev	1.581	1.486
n = 76		

Lab eliminated: 85; 139; 200

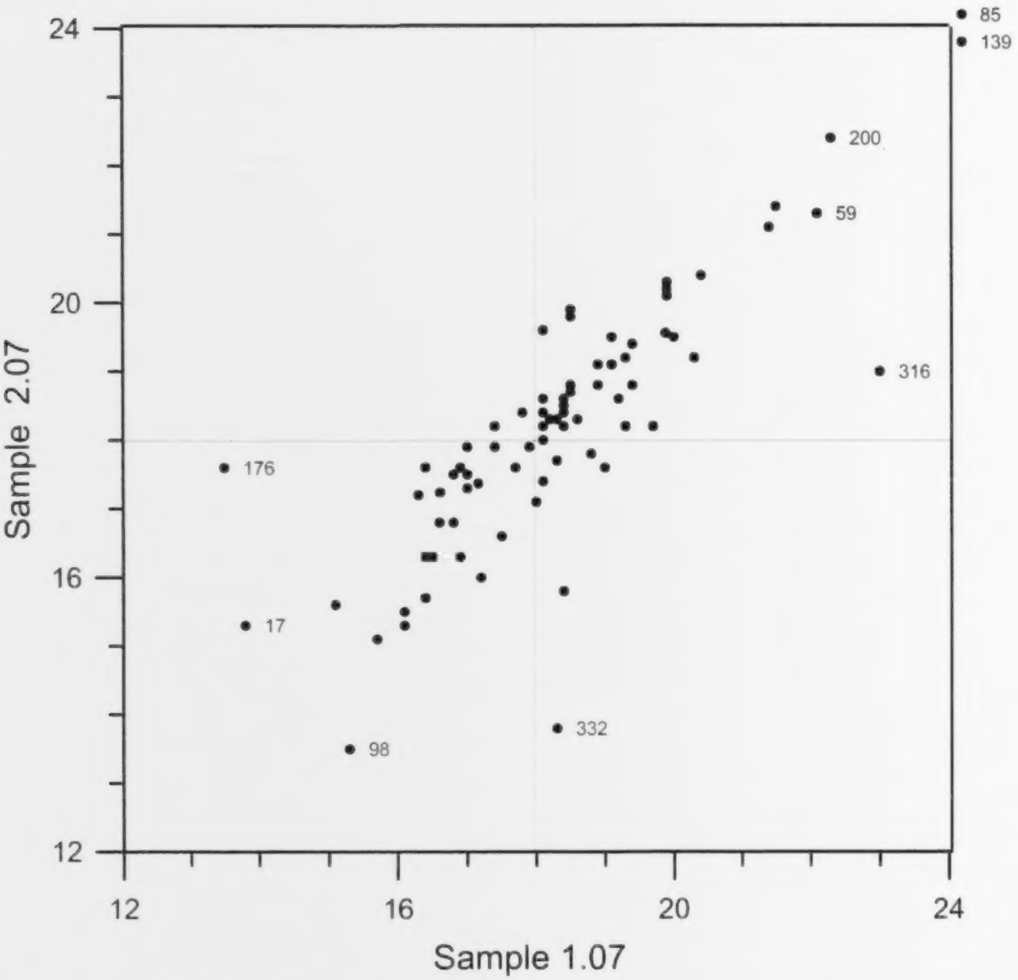


Test 47: Plastic Limit, %

	Mat 1	Mat 2
Mean	18.952	19.144
Median	19.000	19.400
Std Dev	1.329	0.949
n = 77		

Labs eliminated: 98; 100

2007 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

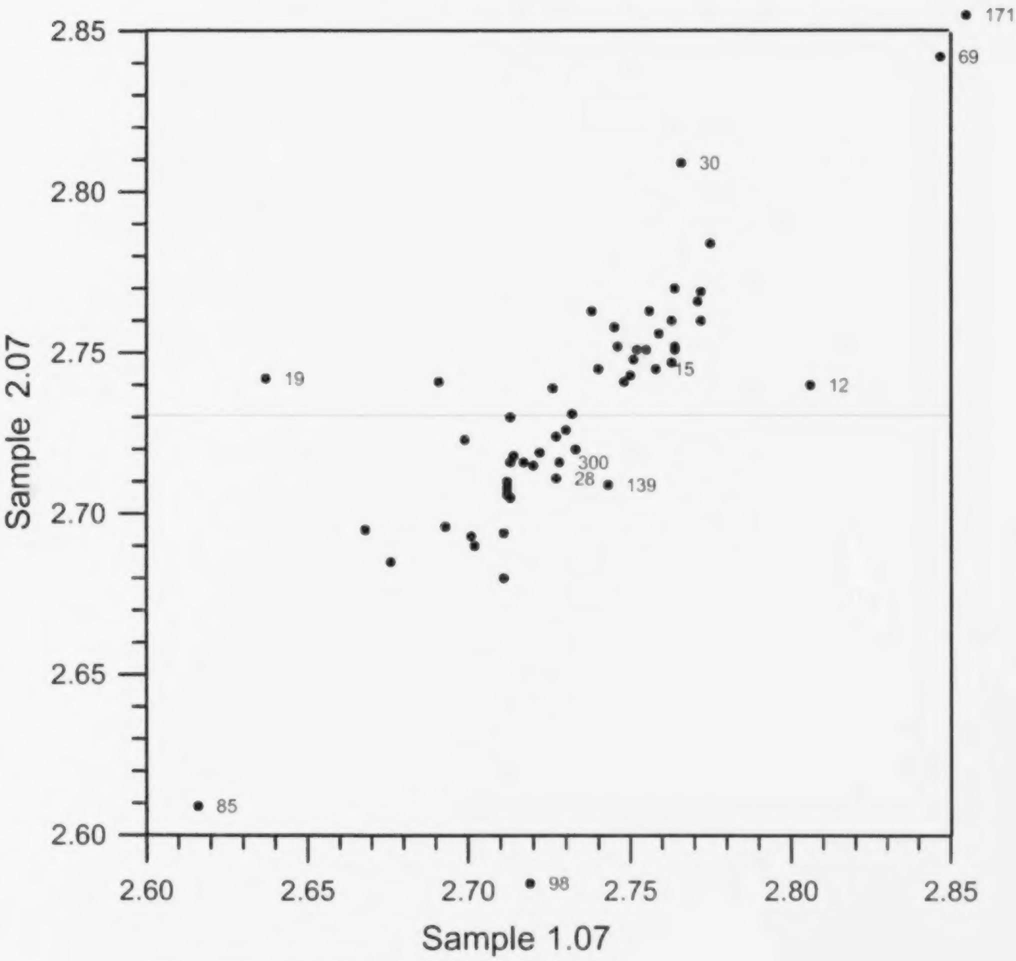


Test 48: Plasticity Index, %

	Mat 1	Mat 2
Mean	18.112	18.112
Median	18.300	18.250
Std Dev	1.343	1.428
n = 70		

Lab eliminated: 17; 59; 85; 98; 139; 176; 200; 316; 332

2007 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

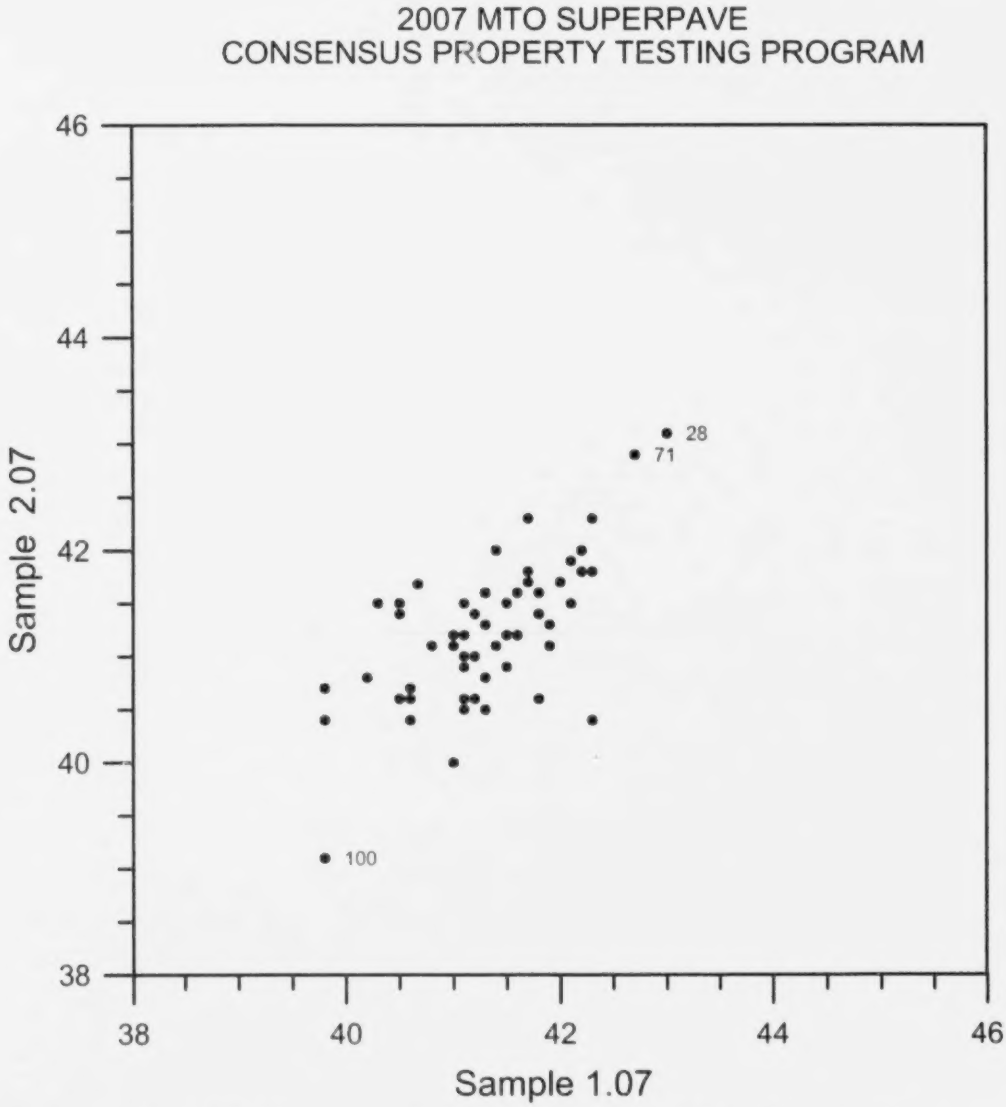


Test 49: Specific Gravity of Soil

	Mat 1	Mat 2
Mean	2.731	2.732
Median	2.722	2.732
Std Dev	0.027	0.026
n = 44		

Labs Eliminated: 12; 15; 19; 28; 30; 69; 85; 98; 139; 171; 300

Appendix D2: Scatter Diagrams

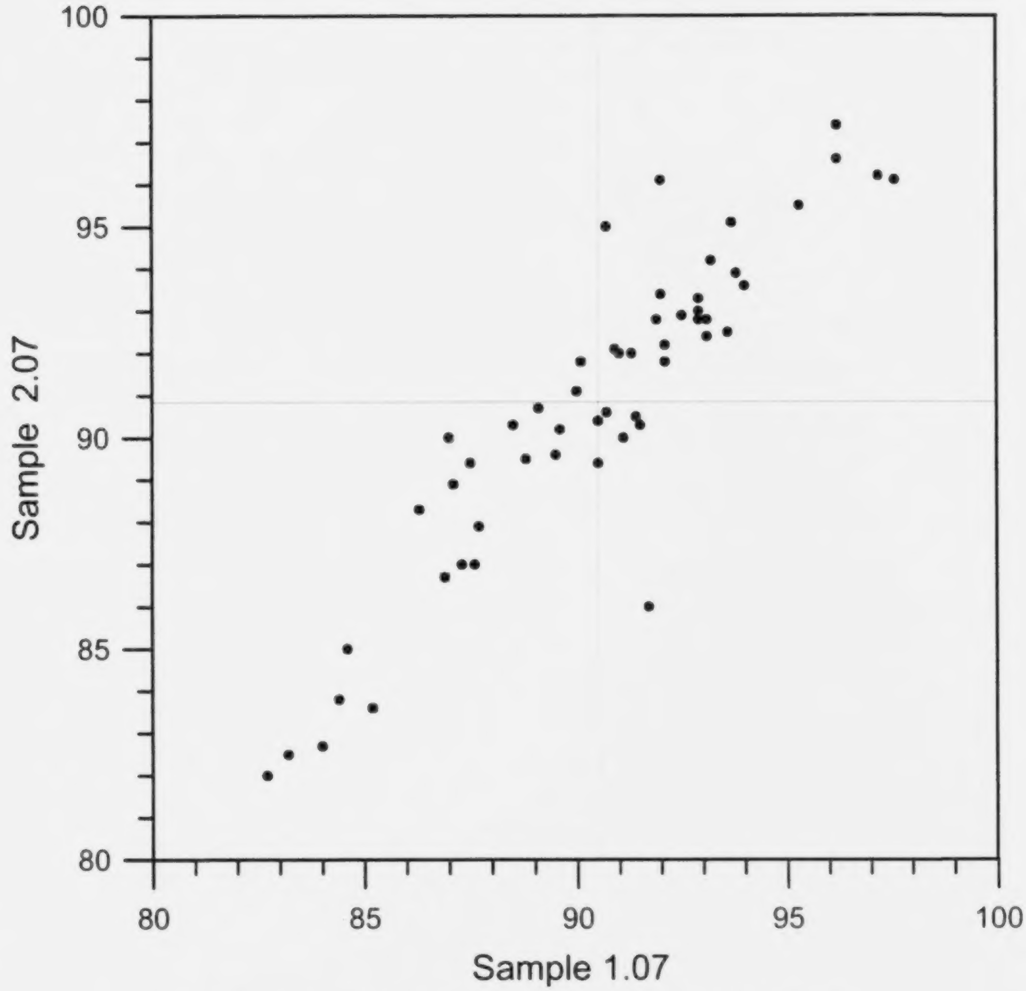


Test 95: Uncompacted Void Content of Fine Aggregate

	Mat 1	Mat 2
Mean	41.321	41.209
Median	41.050	41.150
Std Dev	0.697	0.523
n = 54		

Labs eliminated: 28; 71; 100

2007 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM

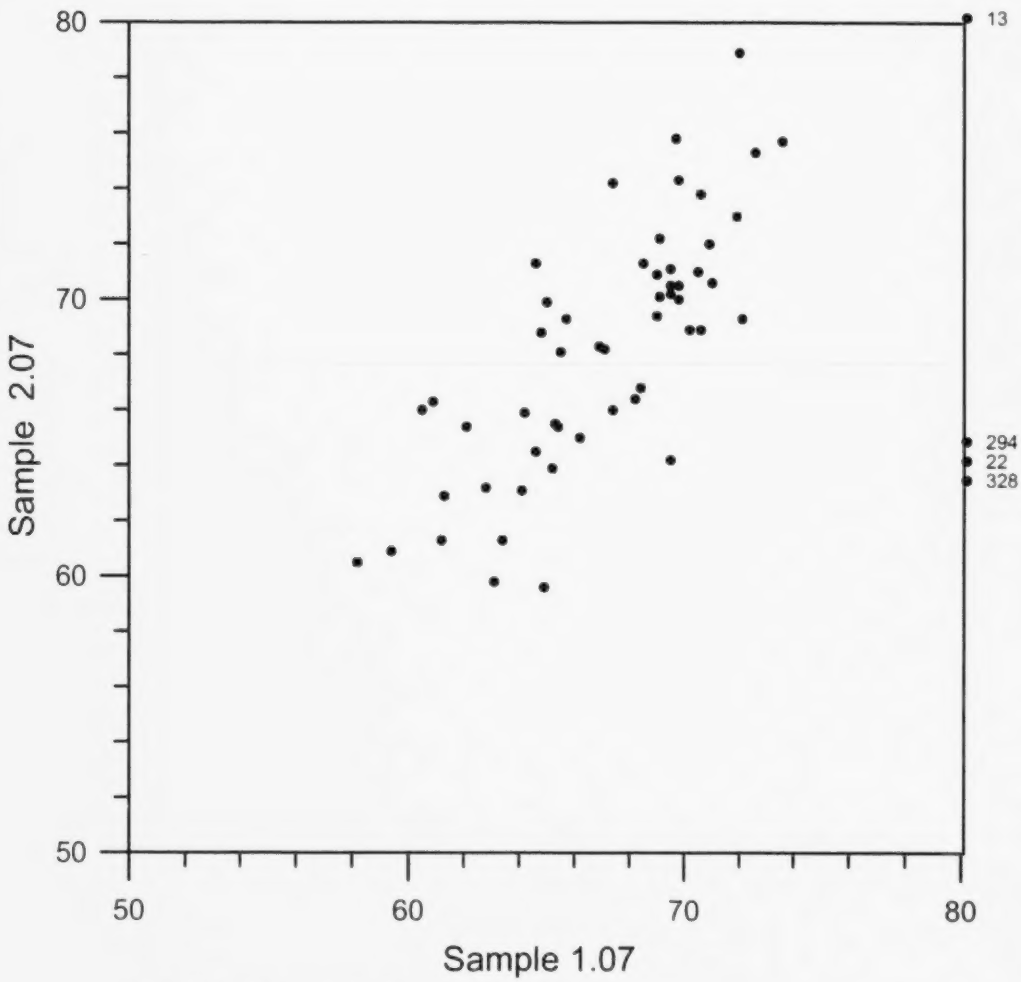


Test 96: Sand Equivalent Value of Fine Aggregate

	Mat 1	Mat 2
Mean	90.548	90.819
Median	90.150	89.700
Std Dev	3.496	3.755
n = 54		

Labs eliminated: None

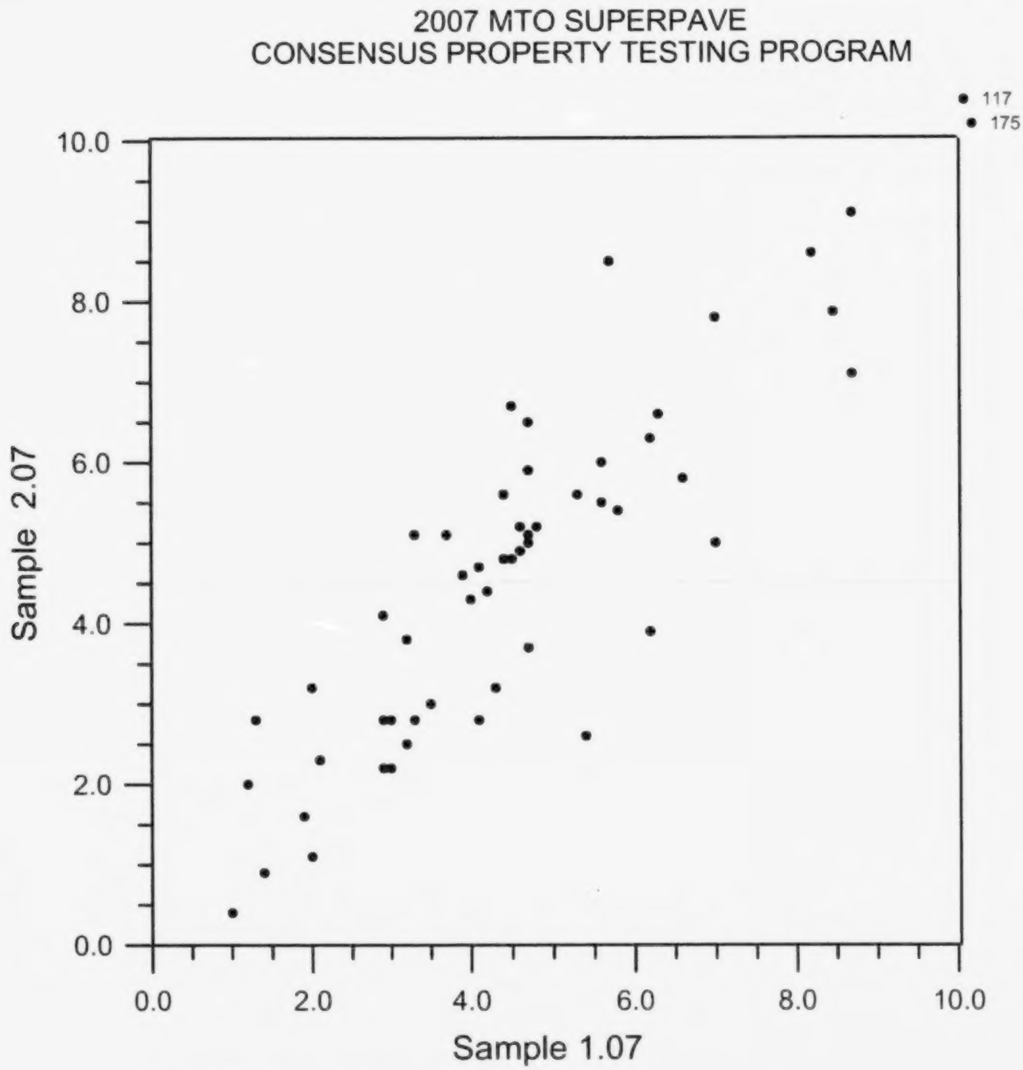
2007 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 97: Percent Fractured Particles

	Mat 1	Mat 2
Mean	66.972	67.856
Median	65.900	69.250
Std Dev	3.679	4.567
n = 54		

Labs Eliminated: 13; 22; 294; 328



Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	4.416	4.530
Median	4.850	4.750
Std Dev	1.861	1.988
n = 55		

Lab Eliminated: 117; 175

Appendix E1: Production Laboratory Ratings

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
4	10	27.8	0	10	10	83
10	10	19.9	10	8		80
12	10	25.9	4	10	8	83
13	3	27.5	10	9	9	84
15	10	25.1	8	9	10	89
16	6	25.9	9	7	10	83
17	9	25.9	10	8		88
18	10	28.4	9	7	10	92
19	10	29.2	10	10	10	99
20	9	27.8	10	9	7	90
22	10	29.5	10	8	10	96
23	7	28.1	10	8	7	86
25	9	26.5	10	10	10	94
26	9	25.4	8	10	10	89
28	4	29.7	10	10	10	91
29	5	24.5	5	10		74
30	9	24.8	9	10	10	90
31	8	27.8	10	8	4	83
32	10	24.3	10	6	10	86
33	5	29.7	10	9	10	91
34	10	27.3	10	9		94
35	10	29.7	10	7	10	95
37	10	27.5	10	9	10	95
38	10	27.8	6	10	9	90
39	10	28.1	9	10	10	96
43	9	26.2	7	10	10	89
44	9	29.5	8	10		94
45	10	26.2	5	10	8	85
46	8	24.5	6	8	9	79
47	10	28.4	9	10	9	95
54	9	27.5	10	10	10	95
55	10	26.2	9	7	8	86
56	10	26.7	9	10	10	94
58	10	27.8	10	6	7	87
59	10	29.5	10	10	10	99
61	10	27.3	10	10	10	96
64	9	26.7	7	10	8	87
68	6	26.5	10	9	8	85
69	10	29.5	10	10	8	96

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
71	6	28.1	10	9	9	**89**
72	10	26.7	7	10	10	**91**
73	6	25.9	9	5	10	**80**
79	10	19.6	10	10	9	**84**
80	10	27.8	10	10	10	**97**
81	7	25.6	10	10	10	**89**
83	10	20.2	9	10	9	**83**
85	10	24.8	10	8		**88**
86	10	27.8	10	9	10	**95**
90	10	29.5	10	10	8	**96**
98	0	25.1	10	10	2	**67**
100	10	28.9	10	10	10	**98**
101	10	29.5	10	10	10	**99**
102	10	22.9	10	7	10	**86**
103	8	23.7	10	10	10	**88**
104	6	28.1	10	10	10	**92**
105	7	22.4	10	10		**82**
107	10	28.6	7	10	10	**94**
108	9	28.6	10	10	10	**97**
110	10	30.0	10	10	10	**100**
112	9	27.3	10	10	9	**93**
113	10	28.4	8	7	10	**91**
115	10	23.5	9	5	10	**82**
116	8	25.1	10	10	10	**90**
117	10	21.0	10	8	9	**83**
120	10	27.8	10	10	10	**97**
124	10	24.3	10	7	10	**88**
126	10	28.9	9	8		**93**
127	6	24.8	10	10	6	**81**
128	8	23.2	10	6	9	**80**
129	10	29.7	9	9		**96**
134	10	24.8	8	9	10	**88**
136	10	24.0	10	9		**88**
137	8	26.5	10	10	10	**92**
138	8	28.4	7	10	10	**91**
139	0	26.5	10	10		**77**
141	10	27.8	10	9	10	**95**
144	10	25.1	9	10	10	**92**
146	10	27.8	9	9	9	**93**
147	10	25.1	10	9	9	**90**
153	10	28.1	8	9	8	**90**
157	10	28.1	10	10	6	**92**
158	7	30.0	10	8	9	**91**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
161	10	29.7	10	4	10	**91**
163	10	29.7	10	10		**100**
164	10	30.0	10	10	10	**100**
167	7	28.9	10	10	10	**94**
169	8	23.7	9	10	10	**87**
171	6	27.5	10	8	10	**88**
172	9	22.9	10	10	10	**88**
175	7	28.9	10	7	10	**90**
176	9	28.6	0	10		**79**
177	9	28.9	10	10	10	**97**
178	9	27.3	9	10	10	**93**
179	8	29.2	9	6	9	**87**
180	10	28.6	10	8	10	**95**
181	4	26.7	10	8	9	**82**
182	8	24.8	10	10	10	**90**
184	9	28.4	10	10	10	**96**
187	10	29.5	10	10	4	**91**
188	10	27.0	10	10	10	**96**
191	10	29.2	9	10	10	**97**
193	10	28.9	10	9	10	**97**
194	10	27.5	10	10	10	**96**
198	0	27.0	10	10	5	**74**
199	10	28.4	10	9	10	**96**
200	10	29.2	10	10	5	**92**
201	10	26.5	10	10		**94**
202	8	28.9	10	9		**93**
204	10	29.5	10	0	3	**75**
205	9	22.9	7	9	10	**83**
207	9	28.4	10	10	9	**95**
208	7	25.9	8	8	8	**81**
210	4	29.2	10	10		**89**
214	10	29.2	10	9	4	**89**
215	10	16.9	10	10	9	**80**
216	10	28.1	10	8	10	**94**
217	9	27.5	10	10		**94**
218	8	27.0	9	10	6	**86**
219	9	28.9	10	10	10	**97**
221	9	26.7	10	10	9	**92**
223	10	24.5	9	9		**88**
224	10	27.8	9	10	8	**93**
228	9	29.7	10	7	10	**94**
232	8	27.3	7	10	7	**85**
234	7	26.7	8	10	10	**88**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
235	10	28.1	9	10	7	**92**
236	10	27.5	10	8	7	**89**
242	9	24.0	10	8	10	**87**
245	9	28.6	10	10	9	**95**
246	10	30.0	10	9	10	**99**
247	9	20.7	9	10	10	**84**
248	10	29.7	9	9		**96**
249	10	27.5	9	9		**93**
250	9	28.6	10	10		**96**
251	10	28.6	10	9		**96**
252	6	26.2	8	4		**74**
254	10	29.5	10	10	10	**99**
255	10	22.9	10	9	10	**88**
256	10	25.6	9	10	10	**92**
257	9	29.7	0	3		**70**
258	8	22.4	10	9	10	**85**
260	8	27.3	10	6	10	**88**
262	0	24.5	1	10	4	**56**
263	10	29.2	10	10	10	**99**
264	10	26.7	9	9	8	**90**
269	9	21.0	10	4		**73**
271	10	21.3	10	9	10	**86**
272	10	29.5	10	10	10	**99**
273	2	24.5	9	10	10	**79**
274	10	27.8	8	10	10	**94**
275	7	24.0	10	10	10	**87**
276	10	27.5	10	10	10	**96**
277	9	26.5	10	10	7	**89**
278	10	26.7	10	10	10	**95**
279	10	27.0	10	10	9	**94**
280	10	27.3	9	10	9	**93**
282	10	27.8	4	9	9	**85**
284	8	29.7	10	8	10	**94**
285	10	21.0	8	9	6	**77**
286	10	28.6	10	10		**98**
287	8	22.1	3	10		**72**
288	10	24.8	4	10	5	**77**
290	10	28.6	10	10	4	**89**
291	10	23.5	0	1	5	**56**
293	10	24.0	10	10		**90**
294	10	29.7	10	10	10	**100**
295	8	28.1	10	10	10	**94**
297	10	26.2	9	10	10	**93**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
299	10	29.7	10	10	10	**100**
300	10	28.6	10	10	6	**92**
301	10	26.2	9	10	10	**93**
302	10	29.5	10	10	10	**99**
303	5	21.0	0	10	4	**57**
304	10	21.3	10	9		**84**
305	10	25.4	5	8		**81**
308	10	29.5	10	10		**99**
309	6	27.0	9	10	10	**89**
311	10	29.2	10	8	7	**92**
313	7	27.0	10	10		**90**
314	10	27.8	10	10	9	**95**
315	7	19.4	10	4	7	**68**
316	10	29.5	10	10	9	**98**
317	10	27.8	10	9	10	**95**
318	9	28.9	9	9	9	**93**
320	9	27.3	10	10		**94**
321	10	29.7	7	10	10	**95**
322	10	29.7	10	10		**100**
323	10	28.4	6	10	10	**92**
324	7	21.0	9	10	10	**81**
325	10	26.2	10	10	10	**95**
326	9	27.0	8	10	10	**91**
327	8	28.1	6	10	9	**87**
328	10	29.5	10	10	10	**99**
329	10	28.4	10	8	10	**95**
330	10	27.8	7	4	10	**84**
331	10	24.0	9	6		**82**
332	10	24.3	10	9	9	**89**
333	8	26.7	3	10		**80**
334	10	29.7	9	10	10	**98**
335	0	21.3	2	5		**47**
337	8	25.1	9	10		**87**
338	9	24.0	10	10	10	**90**
339	9	29.5	10	10	9	**96**
340	10	27.8	10	6	10	**91**

Appendix E2: Full Service Aggregate Laboratory Ratings

FULL SERVICE AGGREGATE LABORATORY RATINGS 2007

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 $MgSO_4$ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
13	3	27.5		9.5	7	10	9	9	0	10	7	10	9.0	9	**80**
15	10	25.1		10	10	8	9	10	10	6	8.5	4	9.7	10	**87**
18	10	28.4		9.5	10	9	7	10	10	3	10	10	9.7	3	**86**
19	10	29.2		5		10	10	10	10	9	10		7.7	10	**93**
22	10	29.5		10		10	8	10	8	9	10		8.7	10	**95**
23	7	28.1		9.5	6	10	8	7	8	10	10	8	7.3	9	**85**
28	4	29.7		8		10	10	10	7	10	7.5		8.0	10	**88**
31	8	27.8	10	6	9	10	8	4	10	10	10	7	7.7	4	**82**
35	10	29.7	10	10	10	10	7	10	10	8	10	10	10.0	9	**96**
37	10	27.5	10	10	10	10	9	10	10	10	9.5	10	10.0	10	**98**
38	10	27.8	10	10	10	6	10	9	9	9	7	10	10.0	7	**91**
46	8	24.5		8		6	8	9	5	0	8		10.0	5	**70**
47	10	28.4	10	7.5	8	9	10	9	8	10	10	9	8.0	10	**92**
56	10	26.7	10	8	9	9	10	10	10	10	10	7	7.7	10	**92**
59	10	29.5		9.5	10	10	10	10	10	10	8	10	10.0	9	**97**
61	10	27.3		9.5	10	10	10	10	10	10	10	10	10.0	6	**95**
69	10	29.5		7.5		10	10	8	9	5	1.5		8.0	8	**82**
79	10	19.6		9.5		10	10	9	8	10	9		10.0	9	**88**
80	10	27.8	5	9	7	10	10	10	10	10	7.5	10	10.0	6	**89**
83	10	20.2		10	10	9	10	9	8	10	8		9.7	9	**88**
86	10	27.8		10		10	9	10	9	10	9.5		10.0	7	**94**
98	0	25.1		2.5	0	10	10	2	9	0	2.5	10	2.7	7	**54**
100	10	28.9		2.5	10	10	10	10	10	8	10			9	**91**
101	10	29.5	7	10	10	10	10	10	9	10	10	10	10.0	10	**97**
107	10	28.6		10	9	7	10	10	10	10	10	10		10	**96**

Appendix E3: Soil Laboratory Ratings

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
12	8.8	7.0	0	53
15	10.0	10.0	0	67
18	9.8	8.7	10	95
19	9.8	10.0	5	83
20	7.4	8.3	9	82
22	9.8	10.0	10	99
23	9.2	8.3	6	78
28	9.2	10.0	0	64
29	10.0	8.0	10	93
30	9.8	9.7	0	65
31	5.6	10.0	9	82
32	8.8	10.0	7	86
35	8.6	9.3	10	93
37	9.0	8.7	10	92
38	8.6	10.0	10	95
44	10.0	9.3	10	98
47	8.6	10.0	10	95
54	4.4	8.7	6	64
56	8.6	10.0	10	95
58	9.4	8.3	10	92
59	10.0	5.7	10	86
64	7.6	5.7	9	74
68	9.8	9.3	10	97
69	9.4	10.0	0	65
71	9.4	9.3	8	89
72	9.2	10.0	10	97
79	10.0	9.7	9	96
80	9.4	9.3	9	92
83	7.0	10.0	9	87
85	5.4	2.3	0	26
86	9.4	9.7	8	90
94	10.0	10.0	9	97
98	5.0	3.3	5	44
101	10.0	8.0	9	90
102	9.4	9.0	10	95
112	9.6	9.7	10	98
120	9.2	10.0	5	81
138	8.4	9.0	8	85

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
139	9.2	3.0	0	41
146	10.0	10.0	8	93
171	7.2	10.0	0	57
172	9.6	9.7	10	98
188	10.0	10.0	10	100
208	5.8	9.7	8	78
210	9.6	8.7	10	94
216	9.4	10.0	10	98
260	10.0	9.0	8	90
276	8.8	7.3	10	87
284	5.4	9.0	10	81
285	10.0	10.0	9	97
299	9.8	10.0	10	99
300	10.0	8.0	0	60
301	9.4	9.7	8	90

Appendix E4: Superpave Laboratory Ratings

Laboratory No.	C 1252/T 304 Uncompacted Void Content	D 2419/T 176 Sand Equivalent	ASTM D 5821 % Fractured Particles	ASTM D 4719 % Flat & Elongated	Rating
13	10	10	0	10	**75**
15	10	6	10	10	**90**
18	10	10	10	9	**98**
19	9	9	7	10	**88**
22	9	6	5	10	**75**
25	10	9	10	10	**98**
26	10	9	9	10	**95**
28	2	9	6	9	**65**
31	10	9	10	8	**93**
33	10	10	10	10	**100**
35	9	8	10	10	**93**
37	10	10	9	7	**90**
39	10	10	10	10	**100**
43	10	10	9	5	**85**
47	10	6	9	10	**88**
56	9	10	8	4	**78**
58	10	10	10	7	**93**
59	10	10	10	10	**100**
61	10	4	9	10	**83**
69	8	10	10	10	**95**
71	3	10	8	8	**73**
79	9	10	9	10	**95**
80	9	10	6	10	**88**
83	10	8	10	10	**95**
86	10	6	10	10	**90**
100	2	10	7	8	**68**
112	10	10	5	10	**88**
120	10	10	10	10	**100**
124	9	9	6	10	**85**
157	9	10	10	8	**93**
172	8	9	10	9	**90**
181	10	10	10	10	**100**
182	9	10	10	5	**85**
188	10	9	5	4	**70**
215	7	6	10	7	**75**
216	7	4	10	10	**78**

Laboratory No.	C 1252/T 304 Uncompacted Void Content	D 2419/T 176 Sand Equivalent	ASTM D 5821 % Fractured Particles	ASTM D 4719 % Flat & Elongated	Rating
235	10	7	9	6	**80**
236	8	10	10	9	**93**
245	10	10	10	10	**100**
255	8	10	10	9	**93**
263	7	10	8	8	**83**
271	10	10	8	9	**93**
272	10	10	10	10	**100**
273	10	10	7	10	**93**
285	10	10	10	10	**100**
293	7	10	10	10	**93**
294	8	6	5	10	**73**
295	8	10	10	10	**95**
316	6	10	9	9	**85**
325	7	10	8	6	**78**
327	9	10	10	10	**98**
328	9	5	5	10	**73**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 $MgSO_4$ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
108	9	28.6		9.5	10	10	10	10	8		9.5	10	10.0	10	**96**
110	10	30.0		8.5	7	10	10	10	9	9	9.5		9.3	10	**95**
112	9	27.3		9.5	9	10	10	9	8	10	10	8	9.0	10	**93**
124	10	24.3		10		10	7	10	7	8	10		9.3	10	**89**
157	10	28.1		10	10	10	10	6	10	10	10	10		10	**96**
164	10	30.0		10	8	10	10	10	9	7	9.5	4		7	**89**
172	9	22.9		8	9	10	10	10	10	8	9	10	9.0	9	**89**
177	9	28.9		9		10	10	10	9	10	10		8.3	10	**96**
188	10	27.0	9	9	10	10	10	10	10	10	10	10	10.0	10	**97**
199	10	28.4		10		10	9	10	7	10	8		10.0	10	**94**
205	9	22.9		9.5		7	9	10	10	7	9		9.7	10	**87**
216	10	28.1		10	10	10	8	10	9	10	10	10	8.0	9	**95**
245	9	28.6		9.5		10	10	9	5	5	10		10.0	7	**87**
260	8	27.3		9.5	8	10	6	10	7	10	4	9	8.0	6	**82**
263	10	29.2		9.5	10	10	10	10	10	8	7.5	10	8.0	10	**95**
285	10	21.0		10	9	8	9	6	2	10	10		10.0	10	**82**
295	8	28.1		9.5	10	10	10	10	9	10	9.5	10	10.0	10	**96**
301	10	26.2		10	9	9	10	10	9	10	9.5	10	10.0	10	**95**
316	10	29.5		10	10	10	10	9	10	10	8.5	9	8.0	10	**96**
325	10	26.2		9.5		10	10	10	10	10	9		10.0	8	**94**
326	9	27.0		9		8	10	10	10	5	7.5		9.0	10	**88**